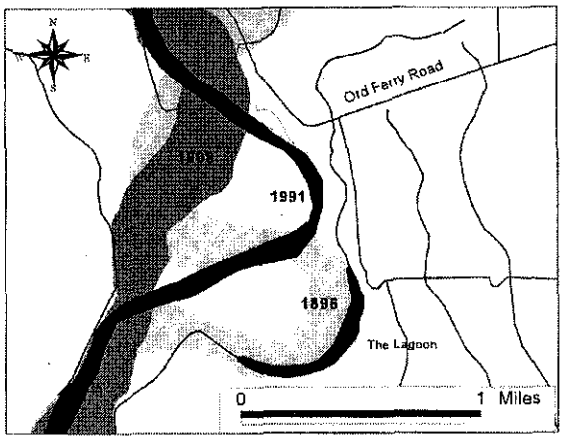
◆ SACRAMENTO RIVER ECOLOGICAL MANAGEMENT ZONE



Sacramento River channel south of Ord Ferry Bridge in 1896, 1908, and 1991 (Sacramento River Advisory Council, 1998).

INTRODUCTION

The health of the Sacramento-San Joaquin Delta is dependent on the rivers and streams that compose its watershed. They provide inflow, sediments, nutrients, spawning and rearing areas for many aquatic species, and riparian corridors that support neotropical bird and other terrestrial wildlife, such as western yellow-billed cuckoo and bank swallow, and invertebrate species. Many estuarine fish species and their foodweb depend on the input from the Sacramento River. The Sacramento River is the largest element of the Delta's watershed, providing about 80% of the inflow to the Delta.

The Sacramento River is also an essential spawning, rearing, and migratory pathway for many anadromous fish populations, such as winter-run, fall-run, late-fall-run, and spring-run chinook salmon, steelhead, white sturgeon, green sturgeon, lamprey, striped bass, and American shad. All of these populations must pass through the Delta and Bay during portions of their life cycle as they migrate to the ocean as juveniles and return as adults to spawn.

Ecological factors having the greatest influence on the anadromous fish in the Sacramento River include streamflow, coarse sediment supply (including gravel for fish spawning and invertebrate production), stream channel dynamics (meander), and riparian and riverine aquatic habitat. Stressors, including dams, legal and illegal harvest, high water temperature during salmon spawning and egg incubation, toxins from mine drainage, hatchery stocking of anadromous fish, and unscreened or poorly screened irrigation diversions, have affected the health of anadromous fish populations.

DESCRIPTION OF THE MANAGEMENT ZONE

The Sacramento River flows more than 300 miles from Lake Shasta to Collinsville in the Delta, where it joins the San Joaquin River. It is a major river of the western United States and the largest and most important riverine ecosystem in the State of California. The river corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of Sacramento. Various cropland habitats occur on flat and gently rolling terrain adjacent to most of this zone. Irrigated crops are mostly rice, grains, alfalfa, and orchard crops. Most of this cropland is irrigated with water diverted from the Sacramento River or its tributaries. Four National Wildlife Refuges (Sacramento, Delevan, Colusa and Sutter) are located either adjacent to or within 5 miles of the Sacramento River.

The Sacramento River Ecological Management Zone includes 242 miles of the mainstem Sacramento River from Keswick Dam near Redding to the American River at Sacramento. (The remaining 60 miles of the lower river downstream of Sacramento are included in the North Delta Ecological Management Unit.) The

mainstem river planning area includes the river channel, gravel bars and vegetated terraces, the 100-year river floodplain, and the geologically defined band of historic and potential river migration (i.e., the meander belt). In the artificially narrow, leveed reach downstream of Colusa and extending to Sacramento, an approximately 1-mile-wide band of river alluvium and historic and potential forest land that borders the levees is also included in this Ecological Management Zone.

This Ecological Management Zone encompasses five Ecological Management Units:

- Keswick to Red Bluff Diversion Dam,
- Red Bluff Diversion Dam to Chico Landing,
- Chico Landing to Colusa,
- Colusa to Verona, and
- Verona to Sacramento.

The National Marine Fisheries Service (NMFS) has determined that critical habitat for the endangered Sacramento winter-run chinook salmon includes the entire Sacramento River from Keswick Dam, river mile (RM) 302 to the Golden Gate Bridge (NMFS 1993). The NMFS has also proposed that all Central Valley stream reaches that are accessible to steelhead be designated as critical habitat, except for the San Joaquin River and tributaries upstream of the Merced River confluence.

Other fish dependent on the Sacramento River Ecological Management Zone include spring-run chinook salmon, late-fall-run chinook salmon, fall-run chinook salmon, steelhead, lamprey, green sturgeon, white sturgeon, American shad, striped bass, American shad and a resident native fish community, including the Sacramento splittail. Due to declining populations sizes, many of these are species of special concern or listed under provisions of the state of federal endangered species acts. One of the important attributes of the zone is its riparian forest, which supports a variety of neotropical migrant bird species, the valley elderberry longhorn beetle, and many other terrestrial species. The riparian vegetation is a significant contributor to the food web and large riparian forests effectively moderate air temperatures.

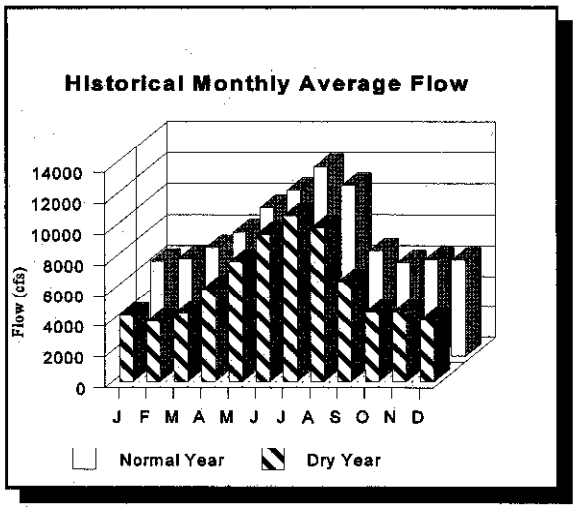
Listing Status of Sacramento River Species

Species	Status of Listing
Winter-run chinook	ESA: endangered CESA: endangered
Spring-run chinook	ESA: proposed endangered CESA: threatened
Late-fall chinook	ESA: proposed threatened
Fall-run chinook	ESA: proposed threatened
Steelhead	ESA: threatened
Green sturgeon	Species of Special Concern
Splittail	ESA: threatened
Bank swallow	CESA: threatened
Western yellow-billed cuckoo	CESA: endangered
Valley elderberry longhorn beetle	ESA: threatened

Sacramento River flow is controlled during much of the year by water releases at Keswick and Shasta dams. Tributaries, including many with no major storage dam, provide a significant quantity of flow accretion, particularly through winter and spring months. Prior to the construction of Shasta Dam, the river flows near Redding had a typical winter and spring high-flow period and a summer low-flow period. Dry-year flows typically reached a peak near a monthly average of 10,000 cubic feet per second (cfs) in March. In more normal years, peak flows reached approximately 20,000 cfs in March. Low summer flows averaged less than 5,000 cfs in dry and normal years.

Since completion of Shasta and Trinity dams, streamflows in the Sacramento River have changed markedly. Late-winter and spring flows in dry and normal years are stored in reservoirs

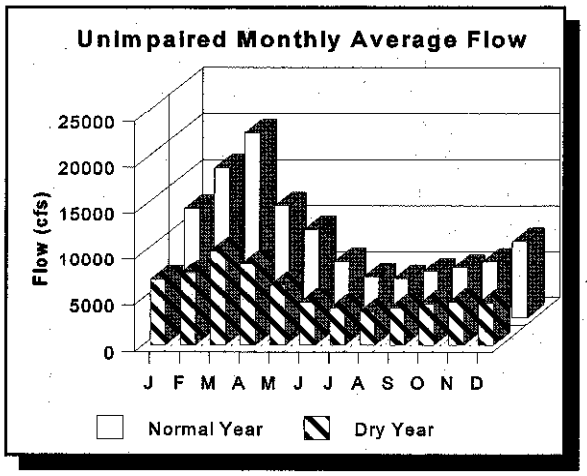
and released during the late-spring through fall irrigation season. In addition to flows released for irrigation in recent years, flows in excess of 10,000 cfs have been augmented to assist in controlling temperature for survival of winter-, spring, and fall-run chinook salmon spawning, egg incubation, and early rearing in the upper river.



Historical Streamflow below Keswick Dam, 1972-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Several water development and flood control projects have dramatically altered the river's natural flow regime, sediment transport capabilities, and riparian and riverine habitats. These projects include the Central Valley Project (CVP), which consists of Shasta, Keswick, and Whiskeytown dams and Red Bluff Diversion Dam (RBDD). They also include the Sacramento River Flood Control Project, which extends 180 miles south from Chico Landing and consists of a series of levees, weirs, and overflow areas, and the Chico Landing to Red Bluff Comprehensive Bank Stabilization Project, which is designed to control lateral river channel migration. This project is about 54% complete but has not been worked on since 1984. The State Water Project (SWP), consisting of Oroville Dam and the associated diversion works, has altered the flow regime below the confluence with the Feather River.

Natural sediments include fine suspended material that causes elevated turbidity to coarser materials that include gravel and cobbles. Bedload sediments also contribute to ecological health by absorbing energy of water and dampen the intensity of flood effects. Gravel recruitment is limited by dams blocking downstream gravel transport, bank protection, and gravel mining on tributaries. Deficiency in spawning gravels reduces the productive capacity of the river. This is especially true in the 15- to 20-mile river reach below Keswick Dam. Spawning gravel may be adequate to support present salmon and steelhead populations. As fish populations increase, gravel replenishment will be necessary. Natural gravel recruitment from tributary streams, particularly from Cottonwood Creek, needs to be protected to ensure that the gravel deficit does not increase. Spawning gravel needs protection from degradation caused by excessive silt entering the river from the tributaries. Watershed protection and comprehensive watershed management plans are needed in all the tributaries to reduce erosion of silts and sands that impair the quality of spawning gravels.



Unimpaired Streamflows below Keswick Dam, 1972-1992 (Dry year is the 20th percentile year; normal is the 50th percentile or median year.)

The Sacramento River and its tributaries above Shasta Dam have a cold temperature regime suitable for year round salmon spawning.

Although the salmon cannot access this reach of the ecosystem, the cold water can be managed using the reservoir and dam to replace the inaccessible upper portions of the watershed. Water temperature in the river is influenced by water releases from Shasta and Keswick dams in drought and consecutive dry or critically dry years. Low flows, combined with warmwater releases, cause the loss of many adult salmon and eggs spawned in the river.

Sacramento River temperature control and power generation requires the installation of a multilevel outlet structure on Shasta Dam and a minimum fall carryover storage in the reservoir of about 2 million acre-feet (MAF). Water temperature in the Sacramento River near Knights Landing can be improved by redirecting the Colusa Basin drain and other agriculture return water to a receiving water other than the Sacramento River or by reuse.

The Colusa Basin drain originates north of Willows in Glenn County. The drain captures waters from the two major diverters located on the west side of the Sacramento River, the Tehama-Colusa and Glenn-Colusa Irrigation districts in Glenn, Colusa, and Yolo counties. Much of the water conveyed through the drain is recaptured and reused before being discharged into the Sacramento River at Knights Landing near RM 90. The combined volume of the water delivered by the two districts can exceed 5,000 cfs during the peak of the irrigation season.

Water temperature is also affected by overhanging vegetation, which shades and moderates heat gain by the water. This shaded riverine aquatic (SRA) habitat has been significantly altered by bank protection and flood control projects. Reestablishing this edge vegetation would significantly improve SRA habitat, woody debris, and other riparian habitat along the Sacramento River, which, in turn, should improve production and survival of salmon and steelhead.

Historically, the riparian forest corridor along the river averaged 4 to 5 miles wide and encompassed a significantly large area. Today only 5% of the forests remain. One-third of the river length has natural banks and floodplain terraces; the other two-thirds have been modified and confined by levees, riprap, and flood control projects. These structures limit the dynamic forces that promote natural habitat succession and regeneration along the river. Channelization and bank protection between Red Bluff and the Delta eliminate and degrade many habitats by increasing the depth and velocity of flow and reducing the hydraulic and substrate diversity associated with more natural or undeveloped river systems. Bank protection also reduces the amount of fresh gravel and shaded riverine aquatic habitat normally available to the river through bank erosion.

Between Colusa and Red Bluff, natural riparian vegetation associated with the existing stream meander corridor plays a part in the natural floodplain process. In turn, the diversity of streamside vegetation and its overall condition are dependent on these same dynamic river processes. Riparian vegetation effectively creates a buffer to decrease local flood flow velocities. This increases deposits of suspended materials derived from eroding banks. This erosion-deposition process builds the midterrace and eventually the high-terrace lands that support climax forest and agriculture. Overbank flooding is essential for the continued health of the riparian system. As silt and seeds are deposited during these overbank water flow events, the native vegetation is rejuvenated.

The fragmentation of the remaining riparian habitat greatly diminishes its ability to support viable wildlife populations. This remaining habitat is being further degraded by human activity and adverse land uses. The combined loss, fragmentation, and deterioration of riparian habitat has caused, or is leading to, the extinction or elimination of several wildlife species. The drastic decline of the Swainson's hawk, once one of California's most abundant raptors, is in part a result of the loss of riparian nesting areas. In 1987,

surveys documented such a low number of yellow-billed cuckoos, that the species appeared to be in danger of immediate extirpation. The elimination of the bank swallow appears likely if bank protection work continues and if mitigation measures are unsuccessful. Various other animal species and some plant species, including the Rose mallow, have population viability problems as a result of adverse human impacts on riparian habitat.

Reestablishing a viable riparian ecosystem along the upper Sacramento River region will increase the acreage and variety of riparian habitats and reverse the decline in wildlife, fishery, and human use values. The U.S. Fish and Wildlife Service (USFWS), the Wildlife Conservation Board (WCB), the National Audubon Society, The Nature Conservancy (TNC), and other private conservation groups are actively seeking to acquire conservation easements or fee ownership of high-priority riparian lands along the Sacramento River as a means to permanently save these lands.

More than 100 miles of the Sacramento River between Red Bluff and Colusa are wholly or partially intact as a dynamic alluvial river meander belt. Although about 20% of its banks are armored by riprap that protects levees and orchards, the river continues to erode its banks naturally and form new banks from gravel and sediment deposits on point bars and terraces. These fluvial geomorphic features support a time-dependent succession of young- and old-growth forest and wildlife habitat that requires 65 to 100 years to reach full maturity (climax succession to valley oak woodland). New sediment and gravel that sustain this process are supplied by a combination of eroding banks along the mainstem river and input from unregulated upstream tributaries. New fish habitat is continually created by migrating gravel riffles and deeper pools formed at bendways, and by mature trees and roots that overhang or topple into the channel as the river naturally erodes through older alluvial deposits supporting climax vegetation.

Improvements in the riparian and stream meander corridors along the Sacramento River are needed to improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements are needed to provide attraction flows for spawning adults and increased spawning habitat. Increasing flows in early spring also assists in successful migration of juvenile chinook salmon and steelhead.

Improved peak flows in late winter and early spring are needed to benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon.

All four races of chinook salmon require improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors, and reduction in the adverse effects of stressors, such as high water temperatures, unscreened diversions, contaminants, and harvest.

Steelhead require improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. Restoring and maintaining natural flow patterns will benefit chinook salmon, but steelhead will benefit only if the natural flows also provide suitably cold water to support year round rearing of juvenile fish. Because of the placement of impassable dams on all major tributaries, approximately 82% to 95% of historical Central Valley steelhead habitat is now inaccessible (Yoshiyama et al. 1996) hence natural populations are mostly relegated to spawning and rearing in low elevation habitats that were historically used mostly as migration corridors. Because of increased summer and fall hypolimnetic releases from reservoirs, flow and temperature conditions in the late summer and fall periods in these reaches can be more beneficial to steelhead than before the dams were built, and small numbers of natural steelhead are able to sustain themselves in these tailwater habitats because of this. Inhospitable conditions in the lower reaches in the

pre-dam years was not an overriding impact to steelhead because they had access to the cooler water habitats of the mid and high elevation tributaries.

Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension.

Improvements in late-winter and spring streamflows and stream meander corridors are needed to benefit American shad spawning and rearing in the Sacramento River.

The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be improved by improvements in riparian habitat areas that result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Specific restoration projects are not proposed for the bank swallow populations along the Sacramento River above the Delta. Potential habitat for bank swallows will be improved by sustaining the river meander belt, and increasing the coarse sediment supply to support meander and coarse sediment erosion and deposition processes.

Other problems in the Sacramento River affecting anadromous fish include poorly screened diversions, seasonal dams installed in rivers, small unscreened diversions, and a limited number of large diversions (>250 cfs). Two diversion dams operate on the river seasonally: Anderson-Cottonwood Irrigation District's (ACID) flashboard dam in Redding that diverts approximately 400 cfs and partially impairs the upstream and downstream migration of salmon and steelhead, and RBDD, the gates of which are in place from mid-May to mid-September to allow diversions up to 3,000 cfs into the Corning Canal and Tehama Colusa Canal. Both the dams and diversions have fish passage facilities and fish screens. Fish passage facilities are inadequate at both facilities, and the screen system at the ACID diversion is not adequate. Although predation problems associated with the dams have been lessened, they still occur.

All other water diversions along the river are shoreline diversions. The largest is GCID's Hamilton City Pumping Plant on an oxbow off of the Sacramento River. It diverts up to 3,000 cfs of water into the Glenn-Colusa Canal. Although many improvements have been made to its screening system, fish protection remains inadequate and improvement efforts continue. An environmental impact report is being prepared to describe actions involved in resolving the problem. In addition, hundreds of unscreened diversions located along the river operate primarily in the spring-through-fall irrigation season. Approximately 20 of these are large (>250 cfs). Efforts are presently being made in cooperation with the irrigators and resource agencies to screen these larger diversions.

The damage to fisheries and the riparian system associated with each of the problems in the upper river varies according to the type of water-year and water delivery operations. The diverse and cumulative nature of these variables requires a holistic remedy to achieve ecosystem restoration in the Sacramento River. The most important factors causing mortality are being addressed in various ways with interim or emergency actions. Fish passage over the 80-year-old ACID diversion dam must be improved. A feasibility study is being conducted to identify alternatives to achieve this goal. ACID canal operations need to be standardized to protect Sacramento River chinook salmon. This involves draining canal water through waste gates only on channels with fish barriers at their confluence with the river, limiting waste-gate releases to 5 or 10 cfs to minimize attraction of salmon from the river, and providing

total containment of canal waters when toxic herbicides are present.

Fish passage at RBDD is a longstanding problem that has been partially solved through reoperation. This interim fix has constrained water diversion, and the longer term resolution needs to incorporate fish passage and survival and water delivery. There is the potential that the U.S. Bureau of Reclamation (Reclamation) research pumping facility at RBDD will allow "gates up" operation at RBDD from mid-September through mid-May and allow Reclamation to fulfill its water contract commitments. With the gates raised, fewer squawfish congregate below the dam, thereby reducing predation on juvenile salmon as they pass under the dam gates. This also provides unimpaired upstream and downstream migration for all anadromous fish in the river. During the period when the gates are open, the gravels in the reach immediately above the dam are available for chinook salmon and steelhead spawning, thereby, avoiding the need to compensate for its loss. Fish losses and delayed migration, however, will still occur during the 4 months the dam gates are lowered.

Natural stream meander, river and floodplain interactions, and riparian plant communities have been damaged by levees, bridges, bank protection, and other types of inchannel structures. Where feasible, natural stream meander should be allowed. To enhance this process, it is likely that riprap would be removed in specific areas formerly subject to bank protection activities. Bridge piers and abutments restrict stream channel processes. Long-term remediation of this problem might include future redesign to accommodate river meander when bridges across the Sacramento River are replaced.

Unnatural levels of predation typically occur in the Sacramento River near instream structures, such as diversion dams, bridge piers and pilings, and support structures for diversion pumps. These provide structure and shade which attract predators. This problem can be reduced in the long term by redesigning, removing, or reoperating these structures to minimize the creation of predator habitat, and by providing escape cover in the form of shaded riverine aquatic habitat.

Competition is primarily between naturally and hatchery produced fish and is typically for food and rearing area. The extent of adverse effects of the interaction between hatchery and natural fish has not been adequately investigated in the Central Valley, although Hallock (1987) reported that yearling steelhead released into Battle Creek consumed large numbers of naturally produced chinook salmon fry. Competition may be a suitable subject for focused research and adaptive management. In the interim, hatchery release strategies and schedules should be evaluated to determine opportunities to reduce or eliminate the potential for competition. Although the potential adverse effects of hatchery fish on wild stocks of salmon and steelhead have not been adequately investigated, there is every reason to expect adverse impacts in addition to competition including predation, interference with reproduction, increased fishing mortality due to mixing in the ocean fishery, disease introduction, loss of local adaptations, and genetic introgression. Hatchery operations should be evaluated and changed to minimize all these potential problems.

Harvest will remain an important element that influences the abundance of Central Valley anadromous fish populations. Harvest strategies need to emphasize the protection of naturally produced stocks with a focus on improving spawner returns for winter-run and spring-run chinook salmon and steelhead. Harvest has been severely restricted in recent years to maximize the return of winter-run chinook spawners, at a high economic cost to fishermen in terms of lost opportunities to harvest abundant fall-run chinook.

Improved management of anadromous fish populations, particularly chinook salmon and steelhead, requires the development and

implementation of a comprehensive coded-wire tagging and recovery program for hatchery stocks. Data derived from these marking programs are important to assess the contributions of hatchery fish to the fisheries and escapements. Experimental studies can be designed to evaluate the interaction of hatchery and wild fish to that future management direction can be established.

In the interim, the annual production levels of each hatchery should be evaluated to ensure that the hatchery goals are consistent with ecosystem restoration and the recovery of listed species. In the longer-term, hatcheries should not produce fish at levels which exceed the mitigation requirements and other production goals.

Toxins from mine drainage on Spring Creek, enter the river by way of Keswick Dam and threaten survival of salmon and steelhead when sufficient dilution flows are not available from Shasta Lake. Recurrent non-point discharges of agricultural pesticides and herbicides occur, which may also adversely affect juvenile fish populations, other aquatic organisms, and riparian and riverine aquatic vegetation.

List of Species to Benefit from Restoration Action in the Sacramento River Ecological Management Zone

- splittail
- green sturgeon
- white sturgeon
- chinook salmon
- steelhead trout
- striped bass
- American shad
- western yellow-billed cuckoo
- bank swallow

Descriptions of Ecological Management Units

Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit

The Keswick Dam to Red Bluff Diversion Dam reach (59 miles from RM 302 to RM 243) includes the mouths of Ash, Bear, Cow, Inks, Stillwater, Anderson, Battle, and Paynes creeks draining Mount Lassen, and of Spring, Clear, and Cottonwood creeks draining the Coast Range and Klamath Mountains. Much of the river in this reach flows through confined canyons, although portions have a broader floodplain. About 4 miles below Keswick Dam, the river widens to about 500 feet before entering the alluvial plains of the Sacramento Valley below Red Bluff. This reach includes much urbanized and residential river frontage, but is not contained by levees as is common on the downstream reach. More than 75% of naturally spawning chinook salmon in the Sacramento River use this reach, while the remaining spawners use the reach from RBDD to Princeton, near Colusa.

Red Bluff Diversion Dam to Chico Landing Ecological Management Unit

The Red Bluff Diversion Dam to Chico Landing Reach (49 miles from RM 243 to RM 194) includes the mouths of eastside tributaries of the Sacramento River that drain Mount Lassen and the northern Sierra Nevada, including Antelope, Mill, Deer, Pine, Rock, and Big Chico creeks. Westside streams that drain the upper valley and parts of the Coast Range include Elder and Thomes creeks. South of Red Bluff, the river meanders over a broad alluvial floodplain confined by older, more consolidated geologic formations (i.e., more cohesive deposits resistant

to bank erosion). The extent of river floodplain and active channel meander belt from Red Bluff to Chico Landing has remained relatively unchanged and includes a significant amount of riparian forest and wildlife.

Chico Landing to Colusa Ecological Management Unit

The Chico Landing to Colusa reach (51 miles from RM 194 to RM 143) includes the mouth of Stony Creek and no other major tributaries. In this reach, most of the high flow during storm runoff events leaves the river along the east bank and enters the expansive floodplain of Butte Basin through three major flood relief outfalls at M&T Ranch, 3B's, and Parrot Ranch, and farther downstream through the Moulton and Colusa weirs near Colusa. Much of the river downstream of Chico Landing has been subject to flood control with an extensive system of setback levees, basin and bypass outflows, and streambank protective measures, such as riprap. However, considerable riparian forest remains within the levees along the active channel. Levees in this reach are 0.25 to 1.0 mile apart.

In the Butte Basin overflow segment, more extensive bank revetment projects installed during the past 30 years by landowners and the U.S. Army Corps of Engineers (Corps) attempt to halt natural channel migration by fixing the river in a static position. It was believed that natural channel migration and meander cutoff might alter flow splits that divert a major portion of river floodflow over three major weirs into Butte Basin, where flooding volumes pose less risk to levee overtopping. Recent hydraulic simulation studies of this reach appear to indicate that the river is somewhat self-adjusting to maintain similar Butte Basin overflow volumes despite specific meander cutoffs that may occur. However, bridge structures (e.g., Ord Ferry Bridge) may be more at risk to major adjustments of the channel position within the floodplain.

Colusa to Verona Ecological Management Unit

The Colusa to Verona reach (63 miles from RM 143 to RM 80) includes the mouth of Butte Creek at the Butte Slough outfall gate, but no significant tributary inflow until the Colusa Basin drain enters the river near Knights Landing at RM 90. In past years outflow at the Colusa Basin Drain has contributed to attraction of adult chinook salmon from their normal migratory pathway of the Sacramento River. Fish that stray into the Colusa Basin Drain are subject to stranding and loss from the spawning population. High flows leave the river by way of the Colusa and Tisdale weirs. Farther downstream, most flow from the Sutter Bypass/Butte Slough and Sacramento River leaves the river again at the 3-mile-long Fremont weir and flows down the Yolo Bypass to the Delta at Rio Vista. Most of the levees in this reach are built close to the main river channel, and little riparian forest or shaded riverine aquatic (SRA) habitat remains. Leveed banks are steep, with extensive riprap and routine removal of volunteer vegetation by local reclamation districts to maintain levee stability on the confined river channel. At the turn of the century, levees were built close to the banks to help move sediment down the river to prevent natural shoals that obstructed commercial river navigation reaching Colusa and Red Bluff. This unit is the most important spawning area for striped bass, and appropriate flow velocities and water temperatures are required for successful striped bass reproduction.

Verona to Sacramento Ecological Management Unit

The Verona to Sacramento Ecological Management Unit (20 miles from RM 80 to RM 60) includes important tributary inflow from the Feather River (and from Sutter Bypass and Butte Creek during high flows) at RM 80 and from the American River at RM 60. High-flow outfall from the rivers and Sutter Bypass enters the Yolo Bypass via the Fremont Weir. As with the upstream reach, most of the levees in this reach

are built close to the main river channel, and little riparian forest or SRA habitat remains.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Sacramento River Ecological Management Zone is to improve, restore, and maintain the health and integrity of the Sacramento River riverine-riparian and tributary ecosystems to provide healthy conditions for sustainable fish and wildlife populations and the plant communities on which they depend.

The pathway to this vision is through preservation and restoration of erosional and depositional channel and floodplain forming processes, riparian and wetland habitats, spawning gravel recruitment, and reducing the extent and influence of stressors. It also includes managing streamflow and flow regime in ways that benefit ecosystem health. Restoring the health and integrity of the Sacramento River Ecological Management Zone will provide a productive and resilient foundation for the recovery of the Bay-Delta estuary and the associated fish, wildlife, and plant resources.

The main stem Sacramento River above Verona may be the most important sturgeon spawning and rearing habitat in the Central Valley, particularly in view of recent information regarding green sturgeon spawning in the river above Hamilton City.

In addition to the vision for the Sacramento River Ecological Management Zone, individual visions have been developed for ecological processes, habitats, stressors, species, and Ecological Management Units. These visions follow.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

VISION FOR THE KESWICK TO RBDD ECOLOGICAL MANAGEMENT UNIT

The vision for the Keswick Dam to Red Bluff Diversion Dam Ecological Management Unit is to protect ecological processes where still intact; allow riparian forests to reach maturity; restore physical and successional processes; and protect and restore freshwater fish habitats that provide for migration, spawning, and rearing for chinook salmon and steelhead.

The potential activities include maintaining a flow pattern that emulates the seasonal hydrologic regime and provides adequate temperatures for rearing steelhead and winter-run chinook salmon to the extent possible while conserving the cool water pool in Shasta Reservoir. This must be done in consideration of the high level of development of water and flood storage in the upper section. Additional activities include cooperative efforts to restore some aspects of the natural hydrologic conditions of the upper Sacramento River. The Anadromous Fish Restoration Plan's (AFRP's) targets of 3,250 to 5,500 cfs from October 1 to April 30 are similar to the rates of unimpaired average flows. In addition to the AFRP base flow minimums, reservoir inflows should be released to the river to provide 8,000 to 10,000 cfs and 15,000 to 20,000 cfs flow events for approximately 10 days in March of dry and below normal years, respectively. Such flow events would support natural processes in the upper river, such as erosion, sediment transport and sediment deposition, and stream channel meander, that depend on natural flow regimes. In addition, this reach contains important year-round spawning and incubation habitat for anadromous salmonids.

The vision highlights the restoration of ecological processes that naturally create and sustain habitats

needed to support and restore the endangered Sacramento winter-run chinook salmon, the threatened Central Valley steelhead, the threatened spring-run chinook populations; and species of special concern such as fall-run chinook, late-fall-run chinook, and green sturgeon. Important ecological functions of flow include maintaining and supplementing the natural stream meander and gravel recruitment processes, transporting and depositing sediment, protecting the limited riparian corridor, providing cool water for all species of fish, and preventing potential catastrophic fish losses resulting from an uncontrolled spill of toxic materials from Iron Mountain Mine (IMM) and Spring Creek debris dam overflows.

Because this Ecological Management Unit encompasses a significant portion of critical holding, spawning, and nursery area required by the endangered winter-run chinook salmon, most of the water diversions in this reach require positive-barrier fish screens installed to protect juvenile salmon and steelhead. A primary concern in this Ecological Management Unit is protecting and enhancing instream gravel resources supplied to the mainstem river by the tributaries.

Nursery areas for juvenile salmon would be improved by restoring or enhancing riparian and riverine aquatic vegetation throughout this unit, particularly in areas immediately up- and downstream of the mouths of some of the tributaries described above.

Vision for the Red Bluff to Chico Landing Ecological Management Unit

The vision for the Red Bluff Diversion Dam to Chico Landing Ecological Management Unit is to protect and expand the quantity and quality of the stream meander corridor; protect the associated riparian forest and allow it to reach maturity; install positive barrier fish screens to protect young fish; maintain flows that emulate the natural hydrology to the extent possible; and recover or contribute to the recovery of threatened, endangered, and special concern species.

The existing meander belt should be protected and improved to sustain the riparian and riverine aquatic habitat component that is important habitat for winter-run chinook salmon and steelhead, other anadromous fish species, riparian forest dependent species, such as yellow-billed cuckoo, other neotropical migrant bird species, and the valley elderberry longhorn beetle. This reach also provides important spawning habitat for anadromous salmonids, particularly fall-run chinook salmon.

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate the natural hydrologic regime to the extent possible and are compatible with the high level of development of water in the upper section. Important considerations include flows needed to maintain natural stream meander processes, gravel recruitment, transport, deposition, and establishment and growth of riparian vegetation.

Because this Ecological Management Unit encompasses an important portion of critical nursery and emigration area required by the endangered winter-run chinook salmon, water diversions in the section will require positive-barrier fish screens to protect juvenile fish. In addition, recent research on non-natal rearing in secondary and ephemeral tributaries indicates that these streams are important rearing habitat and refuges for young chinook salmon and steelhead in the Sacramento River system.

The broad riparian corridors throughout the unit should be connected and should not be fragmented. These corridors connect larger blocks of riparian habitat, typically greater than 50 acres. The riparian corridors should generally be greater than 100 yards wide and would support increased populations of neotropical migrants, such as the

yellow-billed cuckoo, and unique furbearers, such as the ring-tail and river otter. Species such as the bank swallow will benefit from the restoration of processes that create and maintain habitat within this unit.

Nursery areas for juvenile salmon should be improved through the restoration of waterside emergent and riparian vegetation throughout the unit and particularly up- and downstream of the mouths of some of the tributaries described above.

VISION FOR THE CHICO LANDING TO COLUSA ECOLOGICAL MANAGEMENT UNIT

The vision for the Chico Landing to Colusa Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources by preserving, managing and restoring a functioning ecosystem that provides a mosaic of varying riparian forest age classes and canopy structure; maintaining a diversity of habitat types, including forest and willow scrub, cut banks and clean gravel bars, oxbow lakes and backwater swales with marshes, and floodplain valley oak/sycamore woodlands with grassland understory; maintaining uninterrupted gravel transport and deposition; supporting a complexity of shaded and nearshore aquatic substrate and habitats with well-distributed instream woody cover and organic debris; setting back levees; and *the installing positive barrier fish screens.*

Restoring endangered species and species of special concern requires that water management activities be consistent with maintaining ecological processes. These include flows that emulate seasonal patterns typical of the natural hydrologic regime, consistent with the high level of water development in the upper section. Important considerations include flows needed to maintain natural stream meander processes and gravel recruitment, transport and deposition, and maintenance of the limited riparian corridor in this section. A long-term goal would be to set back levees in this section consistent with flood control requirements. This important concept should be integrated into any future flood control planning efforts.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished by several means. These include natural colonization or active restoration of expanded floodplain along channels; reduction of vegetation management by local reclamation districts (consistent with flood control requirements); and enhancement of channel banks by modifying levees and berms to incorporate habitat structures, such as fish groins and low waterside berms that support natural growth and woody debris. However, in the long-term, it may be more beneficial and more cost effective to construct set back levees.

Important elements needed to attain the vision for this unit include specific processes that maintain high-quality habitat for chinook salmon and steelhead, as well as the other anadromous fish species. The continuance of the natural river migration within its meander zone is essential to create and maintain most of these habitats. A mix of solutions will be employed to reduce the need for future additional bank protection or separation of the channel from its floodplain. Floodplain management and detention measures that expand flood protection for valley residents by reducing peak flood stage within the leveed channel will also permit more undisturbed habitat to thrive within the river corridor. Measures will most likely include strategic levee setbacks, expanding flood basin outflow capacity, and new flood easements in basin lands that detain additional flood flows, thereby reducing river stage.

In this unit, broad riparian corridors should be interconnected with narrower corridors that are not subject to fragmentation. These corridors should connect larger blocks of riparian habitat, typically larger than 50 acres. These blocks should be large enough to support the natural cooling of the river by convection currents of air flowing from the cool, humid forests and across the river

water. The wider riparian corridors should generally be greater than 100 yards wide to better support neotropical migrants, such as the yellow-billed cuckoo. Cavity-nesting species, such as the wood duck, and special-status species, such as the bank swallow, will benefit from restoring the processes that create and maintain habitat within this unit. The narrower corridors would be 10 to 25 yards wide.

Nursery areas for juvenile salmon should be improved by restoring waterside emergent and riparian vegetation throughout this unit.

Because this Ecological Management Unit encompasses a significant portion of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish.

Vision for the Colusa to Verona Ecological Management Unit

The vision for the Colusa to Verona Ecological Management Unit is to improve habitat and increase survival of many important fish and wildlife resources; set back levees to improve conditions for riparian vegetation and limited stream meander; provide flows that emulate the natural flow patterns; and install positive barrier fish screens to protect young fish.

Important elements needed to attain the vision for this unit include specific processes that allow the recovery of riparian forest and nearshore aquatic habitats and maintain high-quality habitat for chinook salmon and steelhead and other anadromous fish species. Because this reach is an important seasonal component of the critical migration habitat required by the endangered winter-run chinook salmon, positive-barrier fish screens should be used at water diversions in this section to protect juvenile fish. Adverse environmental effects of the Colusa Basin Drain will be eliminated so that there are no future problems with high water temperatures, contaminants, or fish stranding.

The lack of channel capacity and proximity of levees to the river in the lower two units in this zone are the primary reasons that many habitats are degraded, discontinuous, or absent from this part of the river. There is simply no more room to restore large habitat nodes or corridors without contributing to the flood risk. This is an area where flood control, the potential for set back levees, and ecosystem restoration requirements must be carefully evaluated and integrated. While the potential for meander restoration is less feasible here than on other sections of the river, some degree of restoration is possible.

Vision for the Verona to Sacramento Ecological Management Unit

The vision for the Verona to Sacramento Ecological Management Unit is to recover, contribute to the recovery, or maintain many important fish and wildlife resources that depend on partially operational ecological processes and functions. Elements of this vision include actions to maintain a natural flow pattern; maintain high-quality nursery and migration habitat for adult and juvenile winter-run chinook salmon and steelhead and other anadromous fish species; emulate the natural hydrologic regime to the extent possible; maintain natural stream meander processes and gravel recruitment and deposition; maintain a limited but continuous riparian corridor; provide water temperatures suitable to support chinook salmon, steelhead, and other anadromous fish; reducing potential fish losses resulting from toxic residues from agricultural tailwater; and install positive barrier fish screens to protect young fish.

Closing gaps in the shoreline riparian vegetation and nearshore aquatic habitat will be accomplished (consistent with flood control requirements) by reducing vegetation management by local reclamation districts and by enhancing channelbanks. The letter entails modifying levees

and berms that incorporate habitat structures (such as fish groins and low waterside berms), which support natural growth and woody debris. This section presents the greatest potential for adding oxbows and arms back into the river system. These modification would enhance valley-wide flood control because an increased floodplain would disperse and carry more water. Nursery areas for juvenile salmon would be improved by restoring waterside emergent and riparian vegetation nodes throughout this unit, particularly in areas immediately downstream of the mouth of the American River.

In this unit, narrower riparian corridors should be connected and should not be fragmented. These corridors would connect larger blocks of riparian habitat, typically greater than 50 acres. These blocks would be large enough to support the natural convection currents of air flowing from the forests across the river, causing evaporative cooling of the river. The riparian corridors would generally be 10 to 25 yards wide and would support cavity-nesting species, such as the wood duck, and provide perch and nest sites for raptors, such as the Swainson's hawk. Significant expansion of riparian habitat is only possible if lower river peak floodflow can be reduced, or where levees can be set back several hundred feet at constricted bends to create expanded floodplain nodes within the levees.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Healthy streamflows are natural seasonal patterns in late winter and spring, which include peak flow events that support many ecological processes and functions essential to the health of the anadromous fish populations. The Sacramento River has only a marginally healthy streamflow, because storage reservoirs in the upper watershed reduce flood peaks during the winter and spring, releasing the stored water during the summer months. The vision for these flow patterns can be attained by supplemental short-term releases from the major storage reservoirs to provide flows that emulate natural peak flow events.

COARSE SEDIMENT SUPPLY: The supply of sediments, including gravel, on the Sacramento River is severely impaired by reduced inputs from tributaries and blockage of upstream sources by Shasta Dam and Keswick Dam. Spawning habitat of salmon and steelhead and the production of aquatic invertebrates are dependent on the amount of suitable gravel in the river. Two major sources of sediments include Cottonwood Creek and natural bank erosion. The vision is to use natural processes to provide sediments to the system and to supplement sediment introductions to the extent necessary to emulate natural conditions.

STREAM MEANDER: The meandering river process in the Sacramento River provides much of the habitat required by anadromous fish populations that depend on the river for spawning, rearing, and migration. The meander belt of the upper portion of the river above Chico Landing is reasonably healthy and functioning, while the meander belt of the lower reaches of the river has been greatly limited by river channelization, by a network of confining levees, and associated development in the river floodplain. The vision is to maintain and preserve existing areas of meander and to reactivate meander in other areas that are impaired by bank protection activities.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Natural floodplains above Chico Landing are present, but much of the floodplains below are no longer accessible due to levee construction. Maintaining existing and restoring inaccessible floodplains are important ecological components needed to improve the health of the Sacramento River and the Delta. Actions proposed for protecting the natural stream meander corridor along the Sacramento River will contribute to improved connectivity of the river with its floodplain. The vision is to maintain existing areas where the Sacramento River seasonally inundates its floodplain and to reestablish this seasonal

inundation in smaller areas that will be subject to adaptive management and focused research.

CENTRAL VALLEY STREAM TEMPERATURES: High summer and fall water temperatures continue to threaten the health of anadromous fish populations in the river. Although actions have been taken to reduce high water temperatures, low flows and the release of warm water from reservoirs in drought years remain as very serious threats to the anadromous fish populations of the Sacramento River. The vision is that stream temperatures will be manipulated to the extent possible to meet the biological requirements of aquatic organisms and that a healthy riparian and riverine aquatic corridor will contribute to shading and moderating temperatures gains in the river. Summer and fall stream temperatures are more critical for steelhead than they are for most races of chinook salmon because steelhead juveniles must rear for more than one year in fresh water, hence the vision is also to provide adequate water temperatures year-round.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: The vision is to maintain and restore extensive areas of riparian and riverine aquatic habitats. The primary area for this is along the Sacramento River above Colusa. However, contiguous riparian habitats are extremely important to fish and wildlife throughout all reaches of the Sacramento River, including the 143 miles below Colusa.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of the Sacramento is a fall chinook salmon spawning stream of low gradient while the remainder is a valley floor low elevation stream (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in the Sacramento River will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The Sacramento River has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Water diversions ranging from several cfs to several thousand cfs lead to the loss of millions of juvenile anadromous and resident fish. Significant progress has been made in screening the larger diversions, but screens are needed on the remaining unscreened largest, many medium-sized, and small diversions. Losses at these diversions continue to threaten the health of the anadromous fish populations. The vision is to consolidate, relocate, and screen diversions along the Sacramento River to the extent that they no longer impair other efforts to restore anadromous and resident fishes.

DAMS AND OTHER STRUCTURES: Diversion dams and other structures in the Sacramento River directly and indirectly impair the survival of adult and juvenile anadromous fish. Structures delay or prevent the upstream migration of adult fish during their spawning run, which lowers the reproductive success and viability of the entire population. These diversion structures can injure young fish as they migrate downstream or cause disorientation, making them more susceptible to predation. Predator fish that are not able to migrate upstream may congregate below these structures during times when prey species are abundant. The vision is to modify, remove, or

reoperate structures in a manner that greatly lessens adverse affects on aquatic organisms.

LEVEES, BRIDGES, AND BANK PROTECTION: Most of the biological productivity in large river ecosystems occurs in the floodplain. Levees tend to sever the river from its floodplain and thereby reduce this productivity. Bridges and bank protection limit the lateral migration of the river channel. The vision is to modify or remove structures in a manner that greatly lessens adverse affects on ecological processes, habitats and aquatic organisms.

PREDATION AND COMPETITION: Predation and competition are natural ecological functions. For example, Sacramento squawfish are a large native predatory minnow which evolved along with other fishes in the Sacramento River system. Predation by this species under natural environmental conditions is a natural ecological function. However, large-scale alterations of habitat, streamflow, and the construction of instream structures has provided an advantage to predatory species by eliminating escape cover for young fish and providing types of habitat that harbor predatory fish. Unnatural levels of predation or competition can result in adverse effects to important sport and commercial fisheries and species of concern. The vision is that predation and competition will be lessened by removing, redesigning, or reoperating inwater structures and diversion dams, altering hatchery practices, and restoring riparian and riverine aquatic habitats.

CONTAMINANTS: Heavy metals from Spring Creek are a continuing problem for fish in the upper Sacramento River, as well as non-point sources of contaminants in the lower river reaches, such as agricultural return flow at Knights Landing. The vision is that contaminant effects will be reduced to levels that will not impair efforts to restore anadromous and resident fish populations and other aquatic and terrestrial species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of anadromous fish within the river, estuary, and ocean constrains recovery of wild populations of anadromous fish in the Sacramento River. Reducing the fraction of the wild population harvested will most likely be necessary to allow recovery of populations to a healthy condition. The vision is that harvest strategies will complement efforts to rebuild anadromous fish populations.

ARTIFICIAL PROPAGATION OF FISH: Stocking hatchery-reared salmon and steelhead in the Sacramento River and some of its tributaries supports important sport and commercial fisheries and mitigates loss of chinook salmon and steelhead from the construction of large dams and reservoirs. Hatchery fish also supplement the numbers of naturally spawning chinook salmon and steelhead in the river. However, hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for food and space. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is to operate hatcheries in a manner that is fully integrated into ecosystem management and restoration of naturally spawning anadromous fish.

STRANDING: Chinook salmon and other fish species remain susceptible to stranding as a result of entering the lower end of the Colusa Basin Drain. The vision is to provide a long-term remedy to prevent adult fish, particularly chinook salmon, from entering the drain.

VISIONS FOR SPECIES

SPLITTAIL: The vision for splittail is to recover this federally listed threatened species. Improvements in the riparian and stream meander

corridors along the Sacramento River will improve spawning and early rearing habitat of splittail. Late-winter and early-spring streamflow improvements will provide attraction flows for spawning adults and increased spawning habitat. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger splittail population.

Splittail are presently restricted to a fraction of their historic range. Restoring splittail to their former range outside the Delta is in an important element for this species. Generally, restoration of the species refers primarily to restoration of the reduced Delta populations. Nonetheless, some actions that may assist in restoration of this native species to a portion of its previous upstream range include: creation of meander belts along the Sacramento River by levee setbacks, creation of floodable wetlands in the lower San Joaquin, Tuolumne, and Stanislaus rivers, marsh restoration in the Delta and Suisun Marsh, managing bypasses for fish, and removal of upstream barriers to migration.

Because of its distribution, restoration actions implemented in the following Ecological Management Zones will contribute to the recovery of splittail: Sacramento River, East San Joaquin, San Joaquin River, Sacramento-San Joaquin Delta, Suisun Marsh/North San Francisco Bay, Colusa Basin, Feather River/Sutter Basin, American River Basin, and Yolo Basin. Many of the related actions include restoring ecological processes linked to natural floodplains and flood processes.

WHITE STURGEON AND GREEN STURGEON: The vision for green sturgeon is to recover this California species of special concern and restore population distribution and abundance to historic levels. The vision for white sturgeon is to maintain and restore population distribution and abundance to historic levels to support a sport fishery. Improved peak flows in late winter and early spring will benefit sturgeon spawning. Improved stream meander corridors should also benefit sturgeon. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger sturgeon populations.

Green sturgeon is a legal sport fish in California, Oregon, and Washington. The Bay-Delta system constitutes the southernmost reproducing populations of green sturgeon. There is no direct evidence that green sturgeon have declined in the Sacramento River, but the population is quite small, and a collapse could occur under some conditions. Green sturgeon require additional focused research on life history, distribution and abundance.

Similar to restoration actions for white sturgeon, actions that will contribute to the protection and restoration of green sturgeon will occur in the Sacramento River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

The success of the Department of Fish and Game's white sturgeon management program is clearly indicated by comparison of present day annual numbers of fish harvested, which consistently is nearly 70% of the average commercial catch from 1875 to 1899, about 374,000 pounds. The early unregulated fishery nearly wiped out the populations in a short period of time, while the present managed sport fishery promises to yield continuous returns. The present population goals for white sturgeon are to double the white sturgeon abundance of the average 1967 to 1991 population estimates of fish older than 15 years and to maintain a population that includes at least 100,000 fish that are greater than 102 cm in length.

Although the California Department of Fish and Game and USFWS have set population and harvest goals, actions to accomplish the Ecosystem Restoration Program Plan (ERPP) target will be achieved by restoration actions undertaken and completed in the Sacramento

River, Feather River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay Ecological Management Zones.

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and use fully existing and restored habitat.

Four races of chinook salmon will benefit from improved streamflows, gravel recruitment, water temperatures, riparian and riverine aquatic habitat, and stream meander corridors. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger chinook salmon populations.

Presently, late-fall-run chinook salmon have no special protection. The great majority of late-fall-run chinook appear to spawn in the mainstem Sacramento River during January, February, and March. Late-fall-run chinook abundance has declined due to passage problems at Red Bluff Diversion Dam, loss of habitat, poor survival of emigrating smolts, sport and commercial harvest, and other factors, such as disease and pollutants.

Sacramento River late-fall-run chinook salmon populations will be regarded as healthy when the average number of spawners in the Sacramento River basin exceeds 15,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry (USFWS 1996).

The recovery of the winter-run chinook salmon requires actions to increase their abundance and improve their habitat to the point that the probability of extinction will be very low. Although artificially produced fish may be used to rebuild the population to a level that can satisfy these criteria, direct satisfaction of the criteria will depend on natural reproduction.

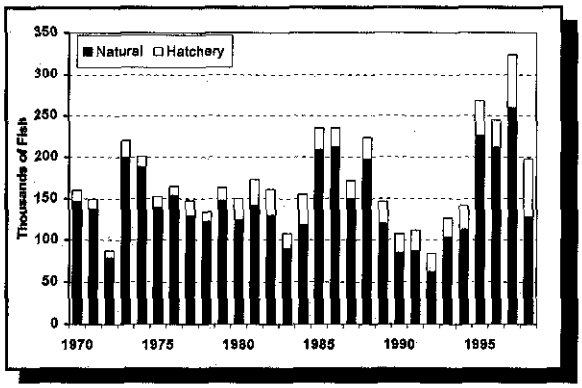
The population criteria proposed to determine when winter-run chinook salmon are recovered require that mean annual spawning abundance over any 13 consecutive years shall be 10,000 females. The geometric mean of the cohort replacement rate (CRR) over the same 13 years shall be greater than 1.0. The variability in cohort replacement rate is assumed to be the same as or less than the current variability. The recovery goal also includes a provision to ensure that the population estimates are sound. The estimation criterion is that there must be a system in place for estimating spawning run abundance with a standard error of less than 25% of the estimate. If this level of precision cannot be achieved, then the sampling period over which the geometric mean of the Cohort Replacement Rate is estimated must be increased by one additional year for each 10% of additional error above 25%.

With respect to the recovery of the Sacramento River winter-run chinook salmon, there are two genetic issues of concern: (1) the effects of past and present reductions in population size on population fitness and population growth rate and (2) the genetic consequences of meeting the delisting criteria.

Programmatic actions that will contribute to the recovery of the winter-run chinook salmon will be implemented in the following Ecological Management Zones: Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh/North San Francisco Bay.

Because of their life-history requirements, typical of all Pacific salmon, Central Valley chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are successfully maintained to varying degrees by existing ecological processes. Even though the quality and accessibility of the habitats have been diminished by human-caused actions, these habitats can be restored through a comprehensive program that strives to restore or

reactivate ecological processes, functions, and habitat elements on a systematic basis, while reducing or eliminating known sources of mortality and other stressors that impair the survival of chinook salmon.



Sacramento Valley chinook Salmon Spawning Population Abundances with Proportion of Estimated from Natural Spawning and Hatchery Production, PFMC 1999.

There are three major programs to restore chinook salmon populations in the Central Valley. The Secretary of the Interior is required by the Central Valley Project Improvement Act (PL 102-575) to double the natural production of Central Valley anadromous fish stocks by 2002 (USFWS 1995). The National Marine Fisheries Service is required under the federal ESA to develop and implement a recovery plan for the endangered winter-run chinook salmon and to restore the stock to levels that will allow its removal from the list of endangered species (NMFS 1996). The California Department of Fish and Game is required under state legislation (the Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988) to double the numbers of salmon that were present in the Central Valley in 1988 (Reynolds et al. 1993).

Each of the major chinook salmon restoration /recovery programs has developed specific goals for Central Valley chinook salmon stocks. ERPP embraces each of the restoration/recovery goals and will contribute to each agency's program by restoring critical ecological processes, functions, and habitats, and by reducing or eliminating stressors. ERPP's approach is to contribute to managing and restoring each stock with the goal of maintaining cohort replacement rates of much greater than 1.0 while the individual stocks are rebuilding to desired levels. When the stocks approach the desired population goals, ERPP will contribute to maintaining a cohort replacement rate of 1.0.

Spring-run chinook salmon are a threatened species under the California Endangered Species Act and is considered a sensitive species by the U.S. Forest Service. Because of their life history patterns, spring-run chinook enter the Sacramento River early in the year and ascend to tributaries where they oversummer to spawn during the following fall. Young fish may rear for a year or longer in the tributaries before entering the Sacramento River during their seaward migration.

The status of a spring-run chinook salmon in the mainstem Sacramento River is uncertain, however, evidence suggests that there may be a significant introgression with fall-run chinook. The role of the Sacramento River in sustaining spring-run chinook salmon is primarily to provide adult fish passage to the tributary streams and to provide rearing and emigration habitat for juveniles during their seaward migration.

Spring-run chinook salmon populations will be considered healthy when the average number of spawners in tributary streams to the Sacramento River exceeds 5,000 fish each year over a 15-year period (five generations times 3 years per generation), with 3 of the 15 years being dry or critically dry. The average number of natural, wild spawners over the 15-year period must not be fewer than 8,000 fish (USFWS 1996).

STEELHEAD TROUT: The vision for steelhead trout is to recover this species listed as threatened under ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats.

Steelhead will benefit from improved streamflows and gravel recruitment in the upper river and improved water temperature and riverine habitat in the upper, middle, and lower reaches of the river. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to stable and larger steelhead populations.

NMFS has identified steelhead populations in the Central Valley as composing a single evolutionary significant unit (ESU) based on a variety of physical and biological data. These data include the physical environment (geology, soil type, air temperature, precipitation, riverflow patterns, water temperature, and vegetation); biogeography (marine, estuarine, and freshwater fish distributions); life history traits (age at smolting, age at spawning, river entry timing, spawning timing), and genetic uniqueness.

The Central Valley steelhead ESU encompasses the Sacramento and San Joaquin Rivers and their tributaries. Recent data from genetic studies show that samples of steelhead from Deer and Mill Creeks and Coleman National Fish Hatchery on Battle Creek are well differentiated from all other samples of steelhead from California.

Within the broad context of ecosystem restoration, steelhead restoration will include a wide variety of efforts, many of which are being implemented for other ecological purposes, or that are nonspecific to steelhead trout. For example, restoration of riparian woodlands along the Sacramento River between Keswick Dam and Verona will focus on natural stream meander, flow, and natural revegetation/successional processes. These will be extremely important in providing shaded riverine aquatic habitat, woody debris, and other necessary habitats required by lower trophic organisms and juvenile and adult steelhead populations.

Operation of the water storage and conveyance systems throughout the Central Valley for their potential ecological benefits can be one of the more important elements in restoring a wide spectrum of ecological resources, including steelhead trout.

STRIPED BASS: The vision for striped bass is to restore populations to levels of abundance consistent with the Fish and Game Commission striped bass policy. This will support a sport fishery in the Bay, Delta, and tributary rivers and reduce the conflict between protection of striped bass and other beneficial uses of water in the Bay-Delta. Striped bass spawning in the Sacramento River is controlled by water temperatures. Fertilized striped bass eggs require sufficient stream flows and velocities to maintain the eggs in suspension. Striped bass will benefit from management of streamflow, water velocities, and water temperatures. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger striped bass population.

Most of the broader restoration actions for striped bass are centered in the Delta. However, the Sacramento River near Colusa is the primary spawning area for adult striped bass. A water temperature of 61°F is required to trigger striped bass spawning in the spring. Therefore, in some years it may be possible to manipulate water temperatures to reach the threshold for spawning. Striped bass eggs require sufficient flow velocity to keep the eggs suspended for two to three days before they hatch. Typically, flow velocity in the Sacramento River is more than adequate to maintain egg suspension.

Very young fish (larvae and fry) are susceptible to entrainment at diversions and are not protected by positive barrier fish screens designed to protect young salmon.

AMERICAN SHAD: The vision for American shad is to maintain an naturally spawning population, consistent with restoring native species, that supports a sport fishery similar to the fishery that existed in the 1960s and 1970s. Improvements in late-winter and spring streamflows and stream meander corridors will

benefit American shad spawning and rearing in the Sacramento River. The vision is that restoration of ecological processes and habitats, along with a reduction of stressors, will contribute to a stable and larger American shad population.

Although American shad is an introduced species, it supports a highly seasonal and popular sport fishery in the Sacramento, Feather, Yuba, and American Rivers. This species will benefit from actions implemented to restore and maintain ecological processes related to streamflow, floodplain processes, and improved nearshore habitat and cover provided by shaded riverine aquatic and woody debris. These actions are being developed throughout the Central Valley and will provide benefits to numerous species and species communities.

WESTERN YELLOW-BILLED CUCKOO: The vision for the yellow-billed cuckoo is to contribute to the recovery of this State-listed endangered species. The yellow-billed cuckoo along the Sacramento River above the Delta is not a species for which specific restoration projects are proposed. Potential habitat for the cuckoo will be expanded by improvements in riparian habitat areas. These improvements will result from efforts to protect, maintain, and restore riparian and riverine aquatic habitats throughout the Sacramento River Ecological Management Zone, thus sustaining the river meander belt, and increasing the coarse sediment supply to support meander and riparian regeneration.

Yellow-billed cuckoos inhabit extensive deciduous riparian thickets or forests with dense, low-level or understory foliage that abuts rivers, backwaters, or seeps. This species is found in the American River Basin, Colusa Basin, Sutter Basin, Butte Basin, and North Sacramento Valley Ecological Management Zones. Overall, the decline of the cuckoo has resulted from the loss of dense riparian habitat along the lower floodplains of larger streams, including those found within the Sacramento-San Joaquin Delta. Conversion of land to agriculture, urbanization, and flood control projects have caused the loss of habitat.

The yellow-billed cuckoo is listed as endangered by the State of California. This listing charges the state with the responsibility to conserve, protect, restore, and enhance the species as well as to acquire lands for its habitat.

Rebuilding the yellow-billed cuckoo population to a healthy state will require a coordinated approach to restoring ecosystem processes and functions, restoring habitat, and reducing or eliminating stressors. Within the broad context of ecosystem restoration, restoration of the cuckoo populations will include a wide variety of efforts, many of which are being implemented for other ecological purposes or which are nonspecific to the cuckoo. For example, restoration of riparian woodlands along the Sacramento River will focus on natural stream meander, flow, and natural revegetational/successional process. These will be extremely important to providing shaded riverine aquatic habitat, woody debris, and other habitat values that contribute to the health of yellow-billed cuckoo populations.

BANK SWALLOW: The vision for the bank swallow is to contribute to the recovery of this State-listed threatened species. Potential habitat for bank swallows will be improved by sustaining the river meander belt and increasing the coarse sediment supply to support meander and natural sediment erosion and deposition processes.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Attaining the vision for the Sacramento River Ecological Management Zone requires near-term funding and implementing actions to achieve the targets. This includes managing water project operations, purchasing title or easements of land from willing sellers, cooperatively developing and implementing a phased fish screening program, acquiring and placing gravel, and performing engineering studies to improve fish passage at diversions and dams. Significant areas of the Sacramento River between Red Bluff and Colusa actively meander. Management actions should aim to protect this functioning process where it is intact, in addition to restoring channel migration within the meander belt.

Several major restoration efforts are either being developed or implemented by state and federal agencies. They will greatly contribute to the success of effort to restore ecological health to the Sacramento River.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and RBDD, water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the Sacramento River Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program, which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

In addition to the Anadromous Fish Restoration and Anadromous Fish Screening programs, the CVPIA requires the Secretary of the Interior to implement a wide variety of Central Valley Project (CVP) operation modifications and structural repairs in the Central Valley for the benefit of the anadromous fish resources. Sections 3406(b)(1) through (21) of the CVPIA authorize and direct the Secretary, in consultation with other state and federal agencies, Indian tribes, and affected interests to take the following actions, all of which will ultimately assist in protecting and restoring a wide variety of fish and wildlife resources, habitats, and ecological function associated with the Sacramento and other rivers in the Central Valley.

- Modify CVP operations to protect and restore natural channel and riparian values
- Modify CVP operation based on recommendations of the USFWS after consultation with the CDFG.
- Manage 800,000 acre-feet of CVP yield for fish, wildlife, and habitat restoration purposes after consultation with USBR and CDWR and in cooperation with the CDFG.
- Acquire water to supplement the quantity of water dedicated for fish and wildlife water needs including modifications of CVP operations; water banking; conservation; transfers; conjunctive use; and temporary and permanent land fallowing, including purchase, lease, and option of water, water rights, and associated agricultural land.
- Mitigate for Tracy Pumping Plant operations.

- Mitigate for Contra Costa Pumping Plant operations.
- Install temperature control device at Shasta Dam.
- Meet flow standards that apply to CVP.
- Use pulse flows to increase migratory fish survival.
- Eliminate fish losses due to flow fluctuations of the CVP.
- Minimize fish passage problems at Red Bluff Diversion Dam.
- Implement Coleman National Fish Hatchery Plan and modify Keswick Dam Fish Trap.
- Provide increased flows and improve fish passage and restore habitat in Clear Creek.
- Replenish spawning gravel and restore riparian habitat below Shasta Reservoir.
- Install new control structures at the Delta Cross Channel and Georgiana Slough.
- Construct, in cooperation with the State and in consultation with local interests, a seasonally operated barrier at the head of Old River.
- In cooperation with independent entities and the State, monitor fish and wildlife resources in the Central Valley.
- Resolve fish passage and stranding problems at Anderson-Cottonwood Irrigation District Diversion Dam.
- Reevaluate carryover storage criteria for reservoirs on the Sacramento and Trinity rivers
- Participate with the State and other federal agencies in the implementation of the on-going program to mitigate for the Glenn-Colusa Irrigation District's Hamilton City Pumping Plant.
- Assist the State in efforts to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions.

In addition to the aforementioned CVPIA actions, Section 3406(e)(1 through 6) directs the Secretary to investigate and provide recommendations on the feasibility, cost, and desirability of implementing the actions listed below. When completed, these actions will provide additional understanding of the overall ecosystem problems and provide additional measures which will benefit anadromous fish.

- Measures to maintain suitable temperatures for anadromous fish survival by controlling or relocating the discharge of irrigation return flows and sewage effluent, and by restoring riparian forests.
- Opportunities for additional hatchery production to mitigate the impacts of water development and operations on, or enhance efforts to increase Central Valley fisheries: PROVIDED, that additional hatchery production shall only be used to supplement or to re-establish natural production while avoiding adverse effects on remaining wild stocks.
- Measures to eliminate barriers to upstream and downstream migration of salmonids.
- Installation and operation of temperature control devices at Trinity Dam and Reservoir.
- Measures to assist in the successful migration of anadromous fish at the Delta Cross Channel and Georgiana Slough.
- Other measures to protect, restore, and enhance natural production of salmon and

steelhead in tributary streams of the Sacramento River.

Section 3406(g) of the CVPIA directs the Secretary to develop models and data to evaluate the ecologic and hydrologic effects of existing and alternate operations of public and private water facilities and systems to improve scientific understanding and enable the Secretary to fulfill requirements of the CVPIA.

Upper Sacramento River Fisheries and Riparian Habitat Advisory Council

Established in 1986 by Senate Bill 1086, this council has develop a restoration plan and undertaken efforts to eliminate structural problems related to fish passage and entrainment (Resources Agency 1989). The present focus of the Council is to develop and implement a program to protect and preserve the stream meander corridor and establish a riparian conservation area from Keswick Dam to Verona.

The vision for this important Ecological Management Zone will assist the Upper Sacramento River Advisory Council's Riparian Habitat Committee (SB 1086 committee) as it progresses with its plan to restore a naturally sustained riparian corridor, including a designated meander belt and extensive forests, between Keswick Dam and Verona.

Sacramento and San Joaquin Basins Comprehensive Study

As a result of State and Federal legislation, the U.S. Army Corps of Engineers and The Reclamation Board of California are conducting the Sacramento and San Joaquin River Basins Comprehensive Study. The Study will identify and evaluate measures to correct system deficiencies and will formulate a Master Strategy for Flood Damage Reduction and Environmental Restoration. This Master Strategy will identify immediate and staged implementation objectives for resolving flooding and interrelated ecosystem problems in the two basins. A cornerstone of this study is a system-wide evaluation to determine the existing capabilities of the flood management systems with an assessment of ecosystem functions intricately linked with the flood conveyance functions of the river systems.

Endangered Species Recovery Plan Implementation

The ERPP will be an important, if not major, component in the successful implementation of recovery measures for species listed under either the State or Federal ESAs. For example, many of the targets and programmatic actions listed later in this section are derived from existing recovery plan. Two plans that have had major influences on the development of programmatic actions include the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes (U.S. Fish and Wildlife Service 1996) and the NMFS Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997).

Because the ERPP addresses endangered species from a broader ecosystem perspective, many restoration actions will benefit broad species communities and the habitats upon which they depend. These include actions to benefit aquatic and terrestrial fish and wildlife species as well as special plants and plant communities.

State and federal agencies responsible for flood control and natural river resources should collaborate with local jurisdictions, landowners, and river conservation organizations to seek systemize solutions, particularly those that emphasize non-structural solutions to flood control and floodplain protection and restoration. In particular, the U.S. Army Corps of Engineers (Corps) should develop a physical model of the river system and its floodplain (similar to the Butte Basin study, but on a larger scale) to test hypotheses for complex rerouting, detention, and bypassing of floodwater. A Sacramento Valley

hydraulic and sediment transport model will be integrated with an evaluation of ecological functions dependent on these physical processes and on the interaction of elements of the ecosystem recovery and land use with floodway capacity.

Completion of studies and subsequent implementation of the U.S. Environmental Protection Agency (EPA) remedies for the IMM Superfund site are needed to attain the safe metal concentrations identified in the basin plan. Pollution control remedies are required at the IMM portal for discharges of remaining sulfide ore deposits inside the mountain, the discharges from tailing piles, and the metal sludge in Keswick Reservoir.

In reaching the vision for this Ecological Management Zone, many cooperative programs need to be developed with federal, state, and local agencies, as well as local interests, such as watershed groups and individual landowners. The cooperative approach also applies to efforts to redirect some industries, such as the aggregate resource industry, to areas outside the active stream channel. These efforts require support from the industry and counties to undertake new programs.

CALFED Bay-Delta Program

CALFED has funded nearly 20 ecosystem restoration projects along the Sacramento River. Most projects screen diversions for irrigated agriculture. Four projects acquire and restore riparian habitat, in conjunction with the SB1086 program. Three projects plan, design, and will construct a new fish ladder at the Anderson-Cottonwood diversion to improve access for winter-run chinook salmon to spawning habitat upstream of the dam.

Linkage to Other Ecological Management Zones

The Sacramento River Ecological Management Zone is dependent on virtually all of its adjacent Ecological Management Zones, which cumulatively contribute to the maintenance of important ecological processes and functions, particularly water, sediments, and nutrients. However, many large, westside streams no longer provide significant sediment and gravel to the mainstem river because of the placement of large reservoirs or sediment control basins, and instream gravel mining that depletes gravel sources in the channel for downstream transport.

Restoring and maintaining ecological processes and functions in the Sacramento River Ecological Management Zone are highly dependent on actions and conditions in adjacent zones. For example, maintaining the riparian forests and stream meander quality of the Sacramento River above Chico Landing is dependent on input of largely unregulated flow and sediments from Cottonwood Creek and several undammed tributaries draining Mount Lassen and the northern Sierra Nevada. Therefore, restoring and maintaining important ecological processes in Cottonwood Creek and other nonregulated tributaries is absolutely essential to maintaining the ecosystem health of the Sacramento River.

Cottonwood Creek is the most important watershed component in the upper river downstream of Shasta Reservoir and controls and supports the maintenance of ecological processes and functions in the upper Sacramento River. The Cottonwood Creek Ecological Management Zone is discussed separately, but its importance to the ecological health of the upper Sacramento River is emphasized here, because it is the largest remaining undammed tributary with natural hydrologic conditions and sediment characteristics. In the winter 1986 flood, more than half the flow (and presumably gravel and

sediment) in the Sacramento River originated in Cottonwood Creek, greater than the volume represented by all other north-valley streams combined.

Likewise, some fish species depend exclusively on the Sacramento River for migration, spawning, and nursery habitat, while some species that use other Ecological Management Zones for spawning use the Sacramento River as primary migration, nursery, and emigration habitat. Other important Ecological Management Zones dependent on the resources of the Sacramento River include the Sacramento-San Joaquin Delta Ecological Management Zone and the Suisun Marsh/San Francisco Bay Ecological Management Zone. These zones, in turn, provide essential foodweb prey species and critical rearing habitat for outmigrating anadromous fish that spawn in the Sacramento River and its major tributaries.

Additionally, stressors important to fish and wildlife species using the Sacramento River during at least part of their life cycle occur outside the identified Ecological Management Zones. For example, ocean recreational and commercial salmon fisheries remove a large portion of the potential spawning adults from the population each year. New harvest management strategies for the ocean fisheries will be needed to augment improvement to inland ecological processes and functions that maintain key habitats for salmon. Water quality of agricultural tailwater throughout the Colusa Basin that reenters the Sacramento River at Knights Landing or Prospect Slough (Yolo Bypass) affects the health and survival of juvenile fish and prey species in the river, depending on the temperature, toxicity level, dilution ratios, and contaminant concentrations and presence of loadings.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: More closely emulate the seasonal streamflow patterns in dry and normal year- types by allowing a late-winter or early-spring flow event of approximately 8,000 to 10,000 cfs in dry years and 15,000 to 20,000 cfs in below normal water-years to occur below Keswick Dam (◆◆).

PROGRAMMATIC ACTION 1A: Provide a flow event by supplementing normal operating flows from Shasta and Keswick Dams in March during years when no flow event has occurred during winter or is expected to occur. Flow events would be provided only when sufficient inflow to Lake Shasta is available to sustain the prescribed releases. This action can be refined by evaluating its indirect costs and the overall effectiveness of achieving objectives.

TARGET 2: Maintain base flows of 6,000 to 8,000 cfs during fall (◆).

PROGRAMMATIC ACTION 2A: Provide flow releases from Shasta Lake and Keswick Dam when necessary to provide the target base flows. Releases would be made only when inflows equal or exceed prescribed releases.

RATIONALE: *Increasing releases from Shasta Reservoir are the only means of maintaining base flows in the upper river. Late-winter or early-spring flow events of sufficient magnitude attract and sustain adult salmon, steelhead, sturgeon, and American shad; improve transport of juvenile fish downstream; sustain riparian habitat; and sustain gravel recruitment, transport, and cleansing processes. The target flows are consistent with historic and unimpaired flows for the Sacramento*

River in dry and normal years. These flows may not occur in some years under the present level of project development and operation. Implementing the target level of the flow event must necessarily be on a conservative basis because of the potential cost to water supply. The fall flow pattern needs to be carefully evaluated to ensure protection for incubating chinook salmon eggs. The chinook salmon that spawn in the fall have eggs in the river that incubate into the winter season. Incubating eggs can be severely damaged when wintertime releases from Keswick Dam are dropped below the fall release levels. Other concerns include maintaining high base flows during the fall would cause temperature control problems in the following year under conditions of low carryover storage in Shasta Reservoir or low inter inflow conditions. The fall flow needs to consider the need for carryover storage to provide temperature control in the following year.

If a flow event of equal or greater magnitude has not occurred between Keswick Dam and Red Bluff by March, then supplementing base flows or augmenting small natural releases or reservoir spills with additional reservoir releases is the only means to provide flow events. Such releases would be used only if there is an equivalent or greater inflow to Lake Shasta. March is the logical month to provide such flows, because it is the month when "natural" flow events occurred historically in dry and below normal years, and because opportunities for such flow to occur "naturally" as a function of normal project operation would have been exhausted by then. Water forecasts of the water-year type (critically dry, dry, below normal, above normal, or wet) are available by February and March. The flow event in March would be expected to proceed unimpaired downstream to the Delta, because few or no diversions from the Sacramento River occur during March. (Note that additional flow events are prescribed for the Feather River in March, which will further enhance Sacramento River flows below its confluence with the Feather River.) A March flow event could also help satisfy Delta outflow requirements.

Maintaining natural base flows will help promote natural channel forming, riparian vegetation, and foodweb functions. Base flows also serve to attract steelhead and fall-run and late-fall-run chinook salmon. Unimpaired base flows in fall are approximately 4,000 cfs to 6,000 cfs in dry years, and up to 8,000 cfs in wetter years. Natural base flows are prescribed only for fall, because, under present project operation, flows in excess of 10,000 cfs are maintained in summer for irrigation and to lower water temperatures for winter-run salmon.

COARSE SEDIMENT SUPPLY

TARGET 1: Increase gravel recruitment in the upper Sacramento River between Keswick Dam and the RBDD by 10,000 to 20,000 cubic yards annually to provide adequate spawning habitat for targeted levels of salmon and steelhead and to sustain stream meander processes below Red Bluff. (This is the estimated amount of spawning-sized gravel captured annually by Shasta Dam.) (◆◆)

PROGRAMMATIC ACTION 1A: Develop a cooperative program to stockpile gravel at strategic locations along the Sacramento River below Keswick Dam where riverflow will move gravel into the river channel to mimic natural gravel recruitment into the upper river. Determine the adequacy of this action and adjust amount and locations as necessary.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to reactivate gravel recruitment to the river by exposing existing sources of river gravel on islands, bars, and banks that have become armored to riverflows. This action should be implemented on a conservative basis, because the availability of such inchannel gravel, costs of activating the gravel, indirect impacts, and potential effectiveness have not been determined.

RATIONALE: *Replenishing gravel supplies to a level sufficient to support target populations of*

salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders in the upper Sacramento River will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Implementation of gravel supplementation projects above RBDD will be subject to adaptive management, with elements that include focused research on sediment transport processes, and monitoring of gravel quality and quantity. Sediment supplementation programs need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as to a different set of indicators, monitoring, and focused research.

On the river side of natural levees in alluvial valleys, fluvial processes typically create dynamic river meander patterns, including oxbow lakes from bend cutoffs, secondary channels that carry flow only during high stage, and nonvegetated point bars where new deposits of sand and gravel collect in low-energy zones of inside bends and bendway crossovers (riffles). In cross section, natural alluvial streams are typically terraced and asymmetrical, with steep banks on eroding outside bends, low-angle banks on inside bends, and several nearly horizontal surfaces corresponding to river floodplain elevations of various magnitude and frequency. If a river has incised (i.e., eroded down below the original channelbed surface) as a result of natural or human-induced factors, the abandoned upper floodplain may become a "terrace" (former floodplain) where riparian forest may then convert to valley oak woodlands or grassland-oak savannah.

The characteristic three-dimensional shape of a river described above (its "fluvial geomorphology" or landforms created by flowing water) is indicative of a river that is in dynamic balance with the interaction of its flood regime, sediment supply, vegetation patterns, climate, and valley slope. Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

TARGET 1: Preserve and improve the existing stream meander belt in the Sacramento River between Red Bluff and Chico Landing by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood management requirements, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 1B: Purchase easements to offset losses to property owners for land lost to meander process.

TARGET 2: Preserve and improve the existing stream meander belt in the Sacramento River between Chico Landing and Colusa by purchase in fee or through easements of 8,000 to 12,000 acres of riparian lands in the meander zone (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to evaluate the feasibility of removing riprap from banks to the extent possible, consistent with flood control management, and reduce effects of other structures, such as bridges, to provide a sustainable meander corridor.

PROGRAMMATIC ACTION 2B: Purchase easements to offset losses to property owners for land lost to meander process.

RATIONALE: *Preserving and improving the stream meander belt below Red Bluff will ensure that this important natural process is maintained in the Sacramento River. This reach is important for spawning and rearing salmon and steelhead. A natural meander process will provide near-optimal habitat for spawning (through gravel recruitment), rearing (channel configuration, cover, and foodweb), and migration. There is limited potential natural channel above Red Bluff. Below Chico Landing, flood control levees limit the potential of restoring the natural meander of that reach. Overall, the program must be consistent with flood control requirements and in the longer-term, should reduce need for future flood control efforts by using natural system resilience and flood control characteristics.*

During the selection process and during implementation, additional benefits will accrue by looking for land within or adjacent to the meander belt which support special status species and to include these areas whenever available in the acquisition. Some the species to be considered include the valley elderberry longhorn beetle, bank swallow, western yellow-billed cuckoo, and giant garter snake.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain floodplains in conjunction with stream meander corridor restoration (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering river channel configurations in leveed reaches of the Sacramento River to increase the areal extent of floodplains inundated during high flow periods.

RATIONALE: *Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Floodplain flooding is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin basin and their landforms. Opportunities to restore or enhance this process are possible by changing landscape features, landforms, and seasonal distribution of flow volume through the system.*

Channelizing and shortening rivers; removing instream vegetation and gravel; and creating symmetrical, trapezoidal channels sandwiched between narrow, steep-sided levees diminish the natural tendency of alluvial rivers to form characteristic compound dimensions and patterns. A channelized river may be relatively stable if the potential for major flood events has been eliminated, sediment input is minimal, vegetation does not naturally grow along the banks, and the channelbed is incapable of incising. The absence of river floodplains and adequate meander width for bar and riffle formation within levee-confined channels prevents or depresses the formation of natural river morphology that is the structural framework for riverine and estuarine fish and wildlife habitats. Stabilizing artificial banks with rock riprap and clearing vegetation further degrades habitat and diminishes natural channel-forming processes.

An important exception here is the existence of the Sacramento River basin overflow system: the Butte basin and Sutter and Yolo Bypasses. Although considerably smaller than their original extent, these three floodplains move and detain floodwaters in volumes and patterns similar to those of presettlement flow, while reducing the risk of overtopping levees near populated areas.

At flood peak, there is approximately five times more flow in the Sacramento River bypass floodplain system than in the main river channel it drains. However, the floodplain bypass system does not exist in the largest historic flood basin of the Sacramento River, the Colusa basin, which is disconnected by levees from the river. Also, the lowest areas of the Sutter basin are outside of the levees and the Sutter Bypass traverses slightly higher ground on a portion of the historical basin floodplain.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain mean daily water temperatures at levels suitable for maintaining all life-history stages of chinook salmon and steelhead in the Sacramento River between Keswick Dam and RBDD in above normal and wet years, and between Keswick Dam and RBDD in other year types (◆◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively develop and implement a balanced river regulation program that provides sufficient carryover storage at Shasta Dam to ensure that suitably low water temperatures are reached to protect chinook salmon and steelhead spawning, incubating eggs, and young fish, particularly in consecutive dry and critically dry years.

RATIONALE: *The temperature objective for the upper Sacramento River is less than or equal to 56°F from Keswick Dam to RBDD for operation of CVP in the State Water Resources Control Board's (SWRCB's) Order 90-5. However, these criteria cannot be met consistently, and other structural facilities and operation measures are needed. These facilities and operational measures must be developed and implemented to enable the long-term attainment of the SWRCB-required temperature criteria.*

A temperature control or "shutter device" has been installed to permit the selective withdrawal of water from Shasta Reservoir over a wide range of depths and temperatures. With this device, warm water could be withdrawn from the upper lake levels when needed, while conserving the deeper, cold water for release when it would most benefit chinook salmon. Operation criteria for temperature criteria needs to include temperature requirements of steelhead trout which spawn in the late-winter/early spring. Controlling temperatures solely for chinook salmon would have serious impacts to naturally spawning steelhead. Operating the temperature control device allows Reclamation greater effectiveness and flexibility in temperature control operations while maintaining hydroelectric power generation. The temperature control device also provides a secondary benefit to anadromous fish by controlling turbidity. Because the temperature control device is installed and operational, operations and carryover storage requirements must be reassessed and new criteria established to optimize attainment of water temperature objectives.

In the long term, Sacramento River water temperatures can be moderated by restoring a healthy riparian forest. Implicit in restoring an extensive riparian forest is a need to reconnect the river with its floodplain to promote natural riparian succession.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Provide conditions for riparian vegetation growth along channelized portions of the Sacramento River (◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to plant vegetation on unvegetated, riprapped banks consistent with flood control requirements. Implementation will occur in phases, results will be monitored and restoration approach will be adjusted as necessary under adaptive management.

PROGRAMMATIC ACTION 1B: Setback levees may be constructed on leveed reaches of the river to provide a wider floodplain and greater development of SRA habitat. Because of the potential indirect impacts on land use and uncertainty of cost and technical feasibility of setback levees, such development will be experimental and conservative, and will depend on adaptive management.

PROGRAMMATIC ACTION 1C: Cooperatively develop and implement a study to determine appropriate conditions for the germination and establishment of riparian woody plants along the river.

TARGET 2: Increase the ecological value of low- to moderate-quality SRA habitat by changing land use and land management practices (◆◆).

PROGRAMMATIC ACTION 2A: Purchase property or easements and allow habitat to improve naturally. Properties to be considered should be developed through a prioritizing process that considers habitat quality and importance, technical feasibility and cost of purchase and improvement, and consent of landowners.

PROGRAMMATIC ACTION 2B: Provide incentives and technical support for private landowners to protect and improve existing SRA habitat.

TARGET 3: Maintain existing streamside riparian vegetation (◆◆◆).

PROGRAMMATIC ACTION 3A: Through purchase, conservation easement, and voluntary participation of landowners, protect SRA habitat from development. Where high-priority properties are already in government ownership or available for purchase or easement, preservation efforts should be undertaken as experiments to develop technical details, cost-effectiveness, and overall approach and consensus for the program. Full implementation of this program would depend on results of experiments and would be subject to adaptive management.

RATIONALE: *Riprapped banks in the leveed section of the river below Chico Landing downstream to Sacramento are the greatest cause of SRA fragmentation. Restoring vegetation will benefit juvenile salmon rearing by providing cover and food, spawning substrate for other fish, such as Sacramento splittail, and refuge for juvenile fish during periods of high water. Improving low- to moderate-quality SRA habitat will benefit juvenile salmon and steelhead by providing improved shade, cover, and food. Wildlife will also benefit from improved habitat. Protecting and improving existing SRA habitat may involve changes in land use. Limited available funds may require that priorities be set, with high-priority, low-cost sites developed initially. For sites where consensus exists, immediate experimental action can be taken. Because of the importance and limited distribution and abundance of SRA habitat, all existing quality habitat should be protected.*

In developing this element of the restoration plan, it is important not to develop just a very long, narrow band of riparian vegetation. Although it needs further development, a "string-of-pearls" approach should be considered. In this concept the long, narrow band of riparian vegetation would be interspersed with larger patches of riparian vegetation. This concept would mesh well with nodes of setback levees to provide a minimal floodplain, seasonal floodplain inundation, and natural or supplemented riparian revegetation.

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of the Sacramento River and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce entrainment of juvenile salmon, steelhead, sturgeon, and splittail into water diversions to levels that will not impair stock rebuilding or species restoration (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to screen all diversions greater than 250 cfs and one- to two-thirds of all smaller unscreened diversions. This programmatic level of action should be sufficient to provide the data necessary to modify this target through adaptive management.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to upgrade screening at diversions with ineffective screening. Where existing screening has proven less than effective and entrainment problems continue, immediate action should be taken to upgrade screens.

PROGRAMMATIC ACTION 1C: Develop a cooperative program to reduce diversions when and where juvenile salmon are present in large or significant numbers. Even with screens, some diversions may pose a threat to young salmon and steelhead, and it may be necessary to modify operations of the diversion. Such determinations will be made after necessary monitoring and evaluation, and on a case-by-case basis. Decisions will be made with agency and stakeholder involvement and with consideration given to appropriate alternatives.

PROGRAMMATIC ACTION 1D: Promote and support relocating water diversions and developing alternate methods of supplying water from the Sacramento River that protect fish but also minimize conflict with maintaining dynamic fluvial processes.

RATIONALE: *Juvenile chinook salmon, steelhead, green and white sturgeon, Sacramento splittail, and American shad are lost at water diversion sites all along the Sacramento River during the spring-to-fall irrigation season. (Note that diversion losses include direct loss into unscreened diversions and other losses associated with the screened and unscreened intake facilities, such as from predators, including squawfish and striped bass.) Reducing entrainment losses to minimal levels is a reasonable target for the short term, given the existing poor health of many of the fish populations that use the Sacramento River and its tributaries for spawning and rearing of young. Emphasis should be on the upper river above Chico Landing, because this is the reach where winter-run chinook young rearing coincides with the spring-to-fall irrigation season.*

Determining which diversions need to be screened will be based on appropriate monitoring and evaluation, with decisions made with agency and stakeholder involvement, and with consideration given to appropriate alternatives. Actions will be taken on a case-by-case basis, with consideration given to results of pilot experiments to determine technical feasibility and cost-effectiveness of screening diversions of different size, type, and location. Priority will be given to screening diversions that pose the most threat and where

screening has been determined to be effective. Emphasis should be given to projects that include the consolidation of several diversion points to a single location.

In application, priority for screening diversions will be based on several criteria including but not limited to the geographical location, the volume of water diverted, the location of the intake in the water column, and the cost effectiveness of the installation. Alternatives to screening will be considered. When a fish screen is installed, it should be tested to determine that it can perform to the criteria of the fish regulatory agencies. After testing has indicated that the screen meets the criteria, monitoring should be conducted to ensure that the screen can meet the criteria under the range of hydrologic conditions expected at the site. When operation monitoring indicates that everything is working satisfactorily, the diverter should routinely inspect the screen to ensure that the facility is undamaged.

DAMS AND OTHER STRUCTURES

TARGET 1: Minimize survival problems for adult and juvenile anadromous fish at RBDD by permanently raising the gates during the non-irrigation season and improving passage facilities during the irrigation season (◆◆◆).

PROGRAMMATIC ACTION 1A: Upgrade fish passage facilities at the RBDD.

TARGET 2: Reduce blockage to fish migrations at the ACID dam (◆◆).

PROGRAMMATIC ACTION 2A: Upgrade fish passage facilities at the ACID dam.

RATIONALE: *At present, the RBDD gates are in the raised position from September 15 through May 14, allowing free passage to about 85% of the spawning run (based on average run timing from 1982-1986). This may have reduced the number of redds (spawning nests created by salmon) being built below the dam. The remaining portion of the run migrating upstream after May 15 is likely to be delayed or blocked from passing the dam.*

Adults that are obstructed from passing the dam are forced to spawn downstream where temperature conditions are typically unsuitable during the spawning and incubation period. Temperatures of 56 °F usually cannot be maintained below RBDD without severely depleting Shasta carryover storage during the winter-run chinook incubation period; eggs and larvae usually have 100% mortality.

Adults that must make repeated attempts to pass the dam, but eventually are successful, undergo physiological stress that may contribute to their reduced fecundity. Because migration of these adults is delayed, the fish are likely to spawn farther downstream where suitable temperatures for spawning and incubation may not be attainable.

Adult chinook salmon must negotiate fish ladders at the ACID dam during the irrigation season (typically April through November) to reach upstream spawning habitat. However, an antiquated ladder on the east abutment of the dam is ineffective in providing safe passage, and a recently installed denil ladder on the west abutment has proved only marginally successful. The ladders at this facility do not provide suitable flows to attract adults, and the ladders are not easily adjustable to compensate for varying flow conditions. A feasibility study is being conducted by the ACID to identify, develop, and evaluate alternatives to resolve adult passage problems.

LEVEES, BRIDGES, AND BANK PROTECTION

TARGET 1: Construct setback levees along leveed reaches of the river as part of the stream meander corridor (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program, consistent with flood control

requirements, to evaluate potential sites for establishing setback levees along leveed reaches of the Sacramento River.

RATIONALE: *Levees, bridges, and bank protection structures inhibit overland flow and erosion and depositional processes that develop and maintain floodplains and allow stream channels to meander. Levees prevent flood flows from entering historic floodplains behind levees, stopping evolution of floodplain habitats dependent on overbank flows. Confinement of flood flows to channels by levees and bank protection structures also increases the fluvial energy of flows that scour or incise channel beds and reduces or halts the rate of channel migration and oxbow formation.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Reduce the area of invasive non-native woody species, such as giant reed (i.e., Arundo or false bamboo) and salt cedar (Tamarisk), that compete with native riparian vegetation (◆◆).

PROGRAMMATIC ACTION 1A: Implement a program along the length of the Sacramento River to remove and suppress the spread of invasive non-native plants that compete with native riparian vegetation.

PROGRAMMATIC ACTION 2B: Implement a program eliminates invasive woody plants that could interfere with the restoration of native riparian vegetation.

RATIONALE: *Invasive non-native plants have altered ecosystem processes, functions, and habitats through a combination of changes such as those to the foodweb and those of competition for nutrients, light, and space. The prescribed actions are primarily to improve habitat for many fish and wildlife species and to support foodweb functions by establishing extensive riparian habitat along the Sacramento River. In most cases, the removal of invasive plants will require the replanting of native vegetation to maintain adequate levels of herbaceous cover, canopy closure, habitat structure, and to limit exotic recolonization.*

PREDATION AND COMPETITION

TARGET 1: Reduce the adverse effects of predatory fish by identifying and eliminating human made in-stream structures or operational conditions that allow unnatural predation rates (◆◆).

PROGRAMMATIC ACTION 1A: Selectively evaluate areas and make physical changes to structures in the Sacramento River, such as bridge abutments, diversion dams, rip-rap banks, and water intakes, that currently may attract predators and provide them with additional advantages in preying on juvenile salmon and steelhead. Pilot studies and evaluations are needed to determine the types of changes required and the potential degree of implementation.

RATIONALE: *Upgrading fish passage facilities at the two diversion dams will reduce delays to upstream migrating winter-run chinook salmon and hindrance of downstream migrating juvenile winter-run chinook salmon. This will contribute to a reduction in predation rates on young fish.*

During operation of RBDD, juvenile chinook are adversely affected while approaching the dam, passing the dam, and moving downstream of the dam. As juveniles migrate toward the dam, they experience increased predation in Lake Red Bluff from predatory fish and birds. Juveniles passing under the lowered dam gates become disoriented because of high water velocities and turbulence, and are subject to heavy predation downstream by squawfish and striped bass. Juveniles bypassed around the dam through the Tehama-Colusa fish bypass system may have improved survival rates because of new facilities and positive-barrier fish screens, but complete evaluations are needed.

To help protect winter-run chinook from predation and other losses associated with passage at RBDD, the dam gates have been raised for varying durations since the end of 1986. Juvenile chinook suffer mortality in passing the dam from squawfish and striped bass predation and disorientation or injury when passing beneath the dam gates or through the fish bypass system. Under the present schedule of gate operations, about 26% of the juvenile outmigrants must pass the dam when the gates are lowered and are susceptible to mortality associated with that passage. In a 1988 study, juvenile hatchery salmon were released above and below the dam to estimate total mortality during dam passage. In all, 16% to 55% fewer fish were recaptured from the releases made above dam than those made below. USFWS determined predation, primarily by squawfish, as the major cause of mortality to juvenile salmon migrating past the dam, whereas the number of deaths from physical injury received while passing under the dam were minor.

CONTAMINANTS

TARGET 1: Reduce losses of fish and wildlife resulting from pesticide, hydrocarbon, heavy metal, and other pollutants in the Sacramento River (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to remedy heavy metal pollution from IMM to meet basin plan standards, and implement reliable and proven remedies that ensure continued treatment and control of heavy metal waste before water is discharged to the Sacramento River.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to eliminate scouring of toxic, metal-laden sediments in the Spring Creek and Keswick Reservoirs.

PROGRAMMATIC ACTION 1C: Control contaminant input to the Sacramento River system by constructing and operating stormwater treatment facilities and implementing industrial best management practices (BMPs) for stormwater and erosion control.

PROGRAMMATIC ACTION 1D: Develop a cooperative program to assess and monitor contaminant input from agricultural drainages in the Sacramento River watershed.

RATIONALE: *Note: Actions proposed here to reduce the adverse effects of contaminants in the Bay-Delta system will be coordinated with recommendations and actions developed by the CALFED Water Quality Common Program.*

The drainage from inactive mines on the IMM Superfund site represents the largest source of pollutant discharge to the Sacramento River. This discharge is at least equal to all the combined industrial and municipal discharges of dissolved metals to the San Francisco Bay and estuary system. This mine water is among the most acidic in the world and contains extremely elevated concentrations of copper, zinc, cadmium, and other metals known to be toxic to fish and wildlife. On occasion, fish deaths (including salmon) may have occurred as toxicity levels have been exceeded and documented in the upper Sacramento River as a result of IMM waste. More frequently, there are documented instances of metal concentrations that exceed toxic levels considered safe for early life stages of salmon.

The wastes from IMM, located in the Spring Creek watershed, are collected in the Spring Creek Reservoir and metered out into the releases of clean water from Shasta and Whiskeytown Reservoirs to achieve the best water quality possible. However, because of the extremely large waste load (averaging more than 1 ton of copper and zinc per day), it has not always been possible to consistently attain the water quality objectives for copper, cadmium, and zinc in the basin plan, and interim criteria have been established until pollution control is completed. Highly toxic conditions are exacerbated when heavy winter rains induce uncontrolled spills from Spring Creek Reservoir, and flows from Shasta and

Whiskeytown Reservoirs are not made available for dilution because of other CVP constraints.

Within the lower portion of the IMM site, remediation must be developed for the metal sludge deposits in Spring Creek Reservoir and in Keswick Reservoir adjacent and downstream of the Spring Creek power plant tailrace. Preliminary monitoring in the Keswick Reservoir has documented that the sludge is highly toxic and that the deposits are extensive and up to 15 feet thick. Under certain conditions, flows from the Spring Creek power plant can mobilize large quantities of the sludge into the river, creating an acute toxicity risk to aquatic species. The sludge deposits can also contribute to chronic toxicity when combined with other sources.

Major sources of pollution include industries, municipalities, and agriculture, which discharge such contaminants as herbicides, pesticides, organic compounds, inorganic compounds, and warm water. Pollution is described as originating from point sources, such as discharge pipes or other localized sources, or from nonpoint sources, which are dispersed. Individual sources of nonpoint pollution may be insignificant, but the cumulative effects can be significant and can contribute high levels of pathogens, suspended solids, and toxins. Major contributors of nonpoint-source pollution to the Sacramento River, Sacramento-San Joaquin Delta, and San Francisco Bay include sediment discharge, stormwater and erosion, and agricultural drainage. Mandatory performance standards are needed for these sources, with flexibility granted to landowners to adopt whatever management practices are best suited for local conditions.

A primary point source of pollution is from municipal treatment plants, which release heavy metal contaminants, thermal pollution, pathogens, suspended solids, and other constituents. Implementing enhanced treatment, pretreatment programs, and tertiary treatment should help to reduce contaminant input.

Sediments constitute nearly half of the materials introduced into rivers from nonpoint sources, such as plowed fields, construction and logging sites, and mined land, and are mainly generated during storm events. Stormwater runoff in urban and developing areas is another major source of sediments and contaminants. Sedimentation from nonpoint sources should be reduced by implementing BMPs for urban and nonurban pollution, and implementing appropriate treatment and technological options that reduce pollutant loads.

An assessment of water quality and impacts from various other agricultural drainages to the Sacramento River is needed. Results from these evaluation programs should generate recommendations for corrective actions. Top priority should be given to the Sutter Bypass, which receives drainwater from rice growing areas and has outflows equivalent to those from the Colusa Basin drain. Assessments should also be conducted on Butte Slough, Reclamation District 108, and Jack Slough.

HARVEST OF FISH AND WILDLIFE

TARGET 1: Reduce illegal harvest of fish species to a minimum to maintain or increase populations by increasing enforcement efforts by 50 to 100% (◆◆◆).

PROGRAMMATIC ACTION 1A: Increase enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop a cooperative program to educate the public on the threats to populations from illegal harvest. Various actions include ad campaigns, signs along streams, and various types of outreach programs to schools, watershed conservancies, and groups.

PROGRAMMATIC ACTION 1C: Provide additional funding for the poaching hotline and rewards for arrest and convictions of poachers.

TARGET 2: Manage the legal harvest of chinook salmon, steelhead, and sturgeon by shifting harvest from natural stocks to hatchery-reared stocks, where possible, or reducing harvest of wild stocks until the naturally produced populations recover (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to mark all hatchery salmon, allowing selective harvest of hatchery fish, while limiting harvest of wild fish. This action should be implemented on a short-term and experimental basis to ensure that it meets its objective and is cost-effective.

PROGRAMMATIC ACTION 2B: Encourage regulatory agencies to change fishing regulations (i.e., by restricting seasons, limits, and gear and reducing harvest of wild fish) to further reduce legal harvest and any ancillary effects of fishing gear or techniques. Restrictions should be severe in the short term. Long-term restrictions would depend on response of populations and effectiveness of restrictions and the degree of effectiveness of the action.

RATIONALE: *Some populations of salmon and steelhead in the Sacramento River are at such depressed levels that drastic reductions in any factors that contribute to mortality are necessary. Harvest management policies have been established by state and federal agencies to minimize mortality on natural chinook stocks, including severe harvest restrictions and size limits. Illegal harvest is known to occur along the Sacramento River. This target will be subject to adaptive management. Mass marking of hatchery steelhead began in 1997 and it should be continued.*

ARTIFICIAL FISH PROPAGATION

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead in the upper Sacramento River will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the costs and benefits of limiting stocking of hatchery-reared salmon and steelhead in the upper Sacramento River. Stocking may be reduced in years when natural production is high in selected populations.

TARGET 2: Limit hatchery stocking to populations that cannot be sustained through natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment winter-run, spring-run, and late-fall-run chinook salmon and steelhead with hatchery-produced smolts during the short-term rebuilding phase of restoration efforts and only when alternative measures are deemed insufficient to provide recovery of the populations. Stocking of hatchery-reared fish will be undertaken as experiments and adjusted or terminated as necessary, depending on results.

TARGET 3: Employ methods to limit straying and loss of genetic integrity of wild and hatchery supported stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Rear salmon and steelhead in hatcheries on natal streams to limit straying. If hatchery augmentation of Sacramento River populations of salmon and steelhead is necessary, then hatcheries should be built on the Sacramento River for that purpose.

PROGRAMMATIC ACTION 3B: Limit stocking of salmon and steelhead fry and smolts to natal watersheds to minimize straying that may compromise the genetic integrity of naturally producing populations.

TARGET 4: Minimize further threats of hatchery fish contaminating wild stocks of salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 4A: Where hatchery production is underway and continues, methods should be adopted and improved for the selection

of an appropriate cross section of the adult population for spawning at the hatchery.

PROGRAMMATIC ACTION 4B: Select spawning adults of appropriate genetic makeup to minimize genetic contamination of existing hatchery and naturally producing stocks of salmon and steelhead. Given the present difficulty of determining genetic makeup of spawning adults selected for hatcheries, this action will necessarily be experimental. Hatchery-reared adults may be preferentially selected or not selected if they are adequately marked or tagged, or have other identifiable feature. Other methods may be developed to genetically categorize naturally produced or hatchery fish.

RATIONALE: *In watersheds such as the Sacramento River, where dams and habitat degradation have limited natural spawning, some hatchery supplementation may be necessary to sustain fishery harvest at former levels and to maintain a wild or natural spawning population during adverse conditions, such as droughts. However, hatchery augmentation should be limited in extent and to levels that do not inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Straying of adult hatchery fish into non-natal watersheds may also threaten the genetics of wild stocks. Hatchery fish may also threaten the genetic makeup of stocks in natal rivers. Some general scientific information and theory from studies of other river systems indicate that hatchery supplementation may limit recovery and long-term maintenance of naturally producing populations of salmon and steelhead. Further research and experimentation are necessary to determine the degree to which this issue is addressed. Long-term hatchery augmentation of healthy wild stocks may genetically undermine that stock and threaten the genetic integrity of other stocks. Spawning and rearing habitats are limited, and adverse conditions may occur in drought or flood years that would undermine the population without additional hatchery production.*

Release of hatchery-reared fish into the upper Sacramento River and its tributaries could lead to a loss of the genetic integrity of wild salmon and steelhead populations. Adults straying into non-natal streams may interbreed with a wild population specifically adapted to that watershed, possibly leading to the loss of genetic integrity in the wild population. Although some irreversible contamination has occurred in salmon and steelhead populations, measures are necessary to minimize further deterioration of contaminated populations and to protect populations that are not contaminated.

Recent returns to CNFH of fall-run chinook salmon seem to indicate that the hatchery is heavily supporting the entire fall-run population, particularly in Battle Creek, all of which probably originated from CNFH. A recent estimate for the rest of the Sacramento River above RBDD, excluding Battle Creek, was only 40,000 fish, which may also have been heavily supported by CNFH production.

Some stocking of hatchery-reared fish may be necessary in the short term to rebuild naturally spawning populations; however, there is a lack of consensus among agencies and stakeholders as to the degree of stocking that is detrimental or necessary to sustain sport and commercial fisheries. This action will necessarily be short term and experimental, with subsequent efforts dependent on results and effectiveness.

Additionally, the relationship of the resident rainbow trout of the mainstem Sacramento River below Keswick (a.k.a. "river trout") with hatchery and naturally spawning steelhead populations should be investigated. There is a substantial number of large, steelhead-sized resident rainbow trout in the upper Sacramento River, and it is unknown if these fish comprise a discreet population, are a component of the steelhead/rainbow trout population, or an artifact

of artificial production. The large number of non-migratory rainbow trout may be a result of ecological conditions that exist in the tailwater reaches below dams, and this needs to be investigated.

STRANDING

TARGET 1: Eliminate the straying, stranding, and loss of adult chinook salmon and other species along the Sacramento River.

PROGRAMMATIC ACTION 1A: Evaluate the feasibility of preventing adult chinook salmon from straying into the Colusa Basin Drain.

RATIONALE: *The straying of adult chinook salmon into the Colusa Basin Drain has long been recognized as a problem. Recent water use practices in the basin have greatly reduced the volume of discharged water, which has reduced the high water temperature and contaminant problems. Still, fish have direct access to the drain under certain flow conditions. This action is consistent with actions described in the Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon (National Marine Fisheries Service 1997) and the Department of Fish and Game anadromous fish restoration plan (California Department of Fish and Game 1993). The feasibility should evaluate water use practices, redirection of waste water, and alternative structures to eliminate entry into the drain.*

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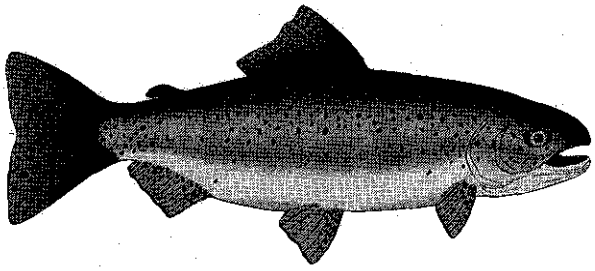
◆ NORTH SACRAMENTO VALLEY ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

The health of the North Sacramento Valley Ecological Management Zone contributes to the health of the Sacramento-San Joaquin Delta in many ways. Ecological processes within this zone contribute sediment, nutrients, and streamflow to the Sacramento River. They also provide important migration, holding, spawning, and rearing areas for spring-, fall-, and late-fall-run chinook salmon steelhead, lamprey, and native resident fish species. Many streams in this zone also provide seasonal non-natal rearing for juvenile steelhead and chinook salmon. Riparian and shaded riverine aquatic habitats provide for many terrestrial species, including neotropical birds, amphibians, and invertebrates.

The North Sacramento Valley Ecological Management Zone encompasses the geographic area and tributary streams generally surrounding the City of Redding and includes the following ecological management units:

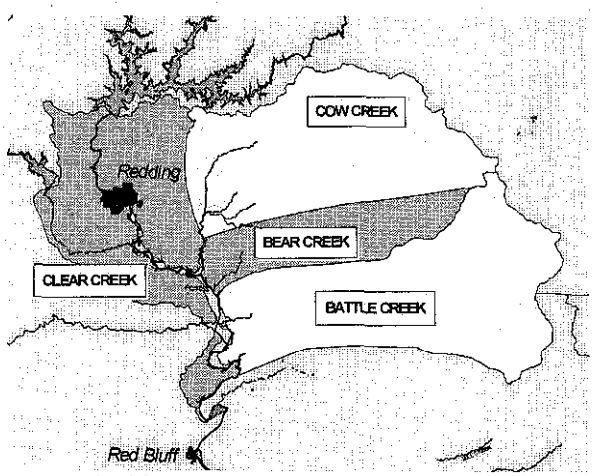
- Clear Creek Ecological Management Unit
- Cow Creek Ecological Management Unit
- Bear Creek Ecological Management Unit, and
- Battle Creek Ecological Management Unit.

DESCRIPTION OF THE MANAGEMENT ZONE

This ecological management zone provides habitats for a significant variety of fish, wildlife, and plant communities, including spring-, fall-, and late-fall-run chinook salmon, steelhead trout, lamprey, native resident fish, neotropical migratory birds, and native anuran amphibians.

Important ecological processes and functions shared by the individual ecological units of the North Sacramento Valley Ecological Management Zone include their respective streamflow patterns and capacity for natural sediment transport; stream meander; gravel recruitment; and stressors, such as water conveyance structures, water diversion, and invasive plant species.

Opportunities to maintain or reactivate these processes and functions are constrained to varying degrees because of past and existing human activities, such as dam construction and gravel extraction from the active stream channel. Many of these constraints are described as stressors that impair ecological function and the creation and



Location Map of the North Sacramento Valley Ecological Management Zone and Units.

maintenance of habitats or that cause direct mortality to important species.

The construction and operation of Whiskeytown and McCormick-Saeltzer dams and past large-scale gravel extraction activities constrain ecological processes and functions in the Clear Creek Ecological Management Unit. Ecological processes and functions on Cow and Bear creeks are impaired by alterations to the runoff pattern resulting from water diversions and land use practices. Small hydropower projects, water diversion and water diversion structures constrain ecological processes and functions on Battle Creek. Past and current operation of Coleman National Fish Hatchery on the lower section of the creek further impairs opportunities to improve the distributions of wild salmon and steelhead stocks.

List of Species to Benefit from Restoration Actions in the North Sacramento Valley Ecological Management Zone

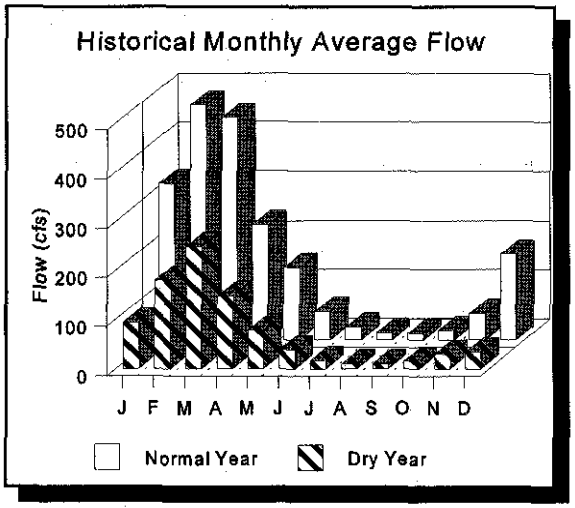
- spring-run chinook salmon
- fall-run chinook salmon
- late-fall-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds

Descriptions of Ecological Management Units

Clear Creek Ecological Management Unit

Clear Creek is a major tributary to the Sacramento River and drains approximately 238 square miles. It originates in the mountains east of Trinity Lake and flows into the Sacramento River near Redding. Whiskeytown Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston Dam through the Clear Creek Tunnel. Whiskeytown Dam, constructed in 1963, is 10 miles upstream of McCormick Dam. The dam diverts more than 80% of Clear Creek's average natural flow to the Spring Creek Powerhouse at Keswick Reservoir on the Sacramento River.

The Clear Creek watershed has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills instead of the Cascade or Sierra crests. The stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,000 to 2,500 cubic feet per second (cfs). In winter months of dry years, average monthly flows reach only 100 to 250 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Whiskeytown Dam, at the lower end of the watershed, receives water diverted from the Trinity River by way of the Clear Creek Tunnel. Most of the Clear Creek and Trinity River water is conveyed from Whiskeytown Lake to Keswick Reservoir on the Sacramento River through the Spring Creek Tunnel. Flows in Clear Creek below Whiskeytown Lake are maintained at 50 cfs from January through October and 100 cfs in November and December, regardless of flow in the upper



Clear Creek Streamflow, 1952-1992 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

watershed. Approximately 10 cfs are diverted from the lower river at McCormick Dam, 8 miles upstream of the confluence with the Sacramento River.

Spawning gravel in the lower Clear Creek drainage has been significantly depleted by mining. Because recruitment of new gravel into this area is restricted by McCormick and Whiskeytown dams, Shasta County adopted an ordinance in 1977 prohibiting new gravel mines in Clear Creek below McCormick Dam. Although the future of this ordinance is uncertain, it constitutes the best protection for spawning gravel. The existing gravel mining operations have refrained from mining in the floodplain for more than 4 years, allowing some riparian reforestation to occur naturally.

Before the construction of Whiskeytown Lake, Clear Creek delivered large amounts of gravel to the lower alluvial reaches and the Sacramento River. Flow regulation since 1963 has greatly reduced the frequency of floodflows capable of moving bedload. The instream gravel is not renewable, because gravel from the upper reaches is trapped in the reservoir. Flow regulation has also allowed dense stands of vegetation to encroach on the main channel, particularly the lower 3 miles before the confluence. This vegetation further reduces velocities and the gravel transport capacity of the stream.

In 1980, the California Department of Water Resources (DWR) estimated that the average annual instream extraction rate of sand and gravel was approximately 75,000 tons per year, equivalent to 20 times the natural transport rate. Subsequent field observations in 1980 and 1994 suggest that gravel mining, flow regulation, and vegetative encroachment combined to reduce the available gravel in Clear Creek. The average annual contribution of gravel to the Sacramento River was estimated to be approximately 5,000 tons per year. In recent year years, gravel operators have halted the practice of instream mining. During this same period, gravels were distributed to the spawning area from tributary stream sources, stream meander, and artificially introduced gravel stockpiles. At this time there are two completed gravel injection projects and one in progress.

Spawning habitat restoration work in Clear Creek is necessary. The work will require placing spawning gravel at appropriate locations. Implementing this restoration will require monitoring spawning gravel to determine whether it successfully meets the needs of adult salmon and steelhead. It also will be necessary to continuously maintain and replenish the gravel. The intent is to provide the habitat and flow necessary to achieve its strategic objective.

The abundance of fall-run chinook salmon spawners in Clear Creek has increased during recent years when the fall flows have been increased by a factor of three. During this interim flow increase, the spawning population estimates have been between 7,000 and 9,000 representing 5% to 8% of the upper Sacramento River salmon population.

Spring-run chinook could have historically migrated to the uppermost reaches of Clear Creek above the town of French Gulch (Yoshiyama et al. 1996). In 1956, Azevedo and Parkhurst (1958) saw spring-run chinook in Clear Creek for the first time since 1949. Passage to the upper watershed was severely restricted by the construction of McCormick-Saeltzer Dam around the turn of the century, then completely eliminated by the construction of Whiskeytown Dam in 1964. It is likely the steelhead also ascended Clear Creek at least as far as French Gulch.

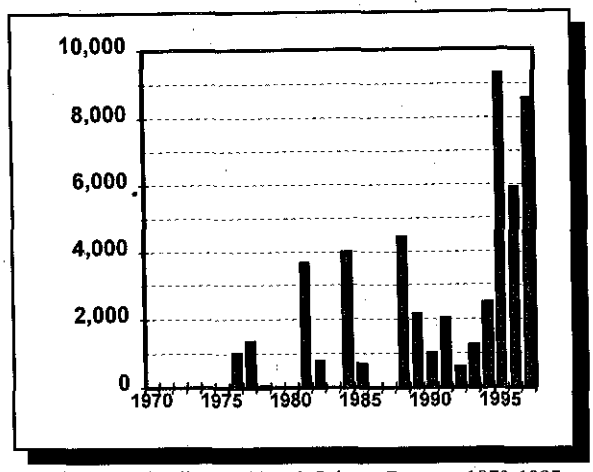
In spite of improved conditions, there are no spring-run chinook salmon in Clear Creek (California Department of Fish and Game 1998) and the status of the steelhead population is unknown. Habitat in Clear Creek has the potential to support spring-run chinook and steelhead if passage at McCormick-Saeltzer Dam is improved to allow adult fish access to the stream reach

immediately below the Whiskeytown Dam. Operation of the dam can provide suitable cold-water habitat downstream to allow adult spring-run chinook to oversummer and then spawn in the fall. The cold water would also support juvenile salmon and steelhead rearing through the summer.

Restoring habitat and increasing flow releases from Whiskeytown Reservoir could significantly improve the present production of chinook salmon in Clear Creek. Steelhead populations would similarly benefit.

Restoring the Clear Creek chinook salmon and steelhead populations has been the focus of fishery management efforts in the upper Sacramento River drainage below Shasta Dam for most of the Twentieth Century. Interest and concern regarding the status of salmon and steelhead in this stream began shortly after the 1903 construction of the McCormick Dam, located 6 miles upstream of the Sacramento River. Early restoration efforts attempted to provide suitable adult fish passage at McCormick Dam, but as watershed and instream habitats continued to decline, the need for additional habitat restoration efforts increased. The cumulative effects of water export, gold mining, gravel extraction, timber harvest, road building, and the construction of Whiskeytown Dam have contributed to the decline of the Clear Creek anadromous fishery. Only in recent years has there been a recognition of the complexity of the problem and a multiagency cooperative effort to seek corrective actions designed to restore habitat and fish passage in Clear Creek. Local environmental groups and individuals have also been seeking solutions to the problems limiting Clear Creek's fishery potential.

The California Department of Fish and Game (DFG) manages Clear Creek for fall- and late-fall-run chinook salmon and steelhead trout. The stream is uniquely suited for intensive management because of its ability to provide cool temperatures in the upper reach and adequate flows in fall. The stream below McCormick Dam



Clear Creek Fall-run Chinook Salmon Returns, 1970-1997.

is most suitable for fall- and late-fall-run chinook salmon spawning, but unsuitable for oversummering spring-run chinook salmon or for year-round rearing of steelhead. Conditions above the dam are suitable for steelhead and spring-run chinook salmon.

McCormick Dam impairs the up- and downstream passage of juvenile and adult anadromous fish. Removal of the dam would improve passage and survival of chinook salmon and steelhead and improve the transport of natural sediments from the stream reach above the dam to the lower reach.

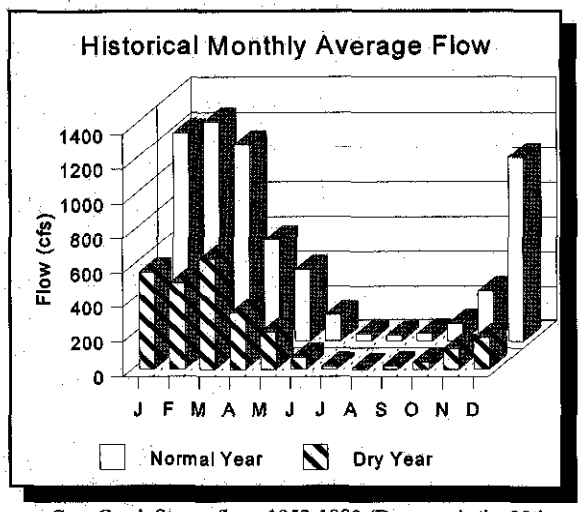
COW CREEK ECOLOGICAL MANAGEMENT UNIT

Cow Creek flows through the southwestern foothills of the Cascade Range and enters the Sacramento River 4 miles east of the town of Anderson in Shasta County. Cow Creek encompasses five major tributaries: Little (North) Cow, Oak Run, Clover, Old Cow, and South Cow creeks. The drainage area is approximately 425 square miles, and the average discharge is 501,400 acre-feet per year.

Cow Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than from the Cascade or Sierra crests. Near its mouth (where the gaging

station is located), the stream is nearly dry during the summer and fall months of dry years. USGS surface water records show the mean August flow of 35 cfs, September at 45 cfs, and October at 131 cfs with a maximum August flow of 115 cfs and a minimum of 1 cfs.

In wetter years, flows in winter months average 2,600 to 6,000 cfs. In winter months of dry years, average monthly flows peak at 500 to 650 cfs. In the driest years, winter monthly average flows reach only 80 to 120 cfs. Small agricultural diversions contribute to lower flows in summer and fall. A Pacific Gas and Electric Company (PG&E) hydropower project diversion reduces flow on a 10-mile section of the South Fork.

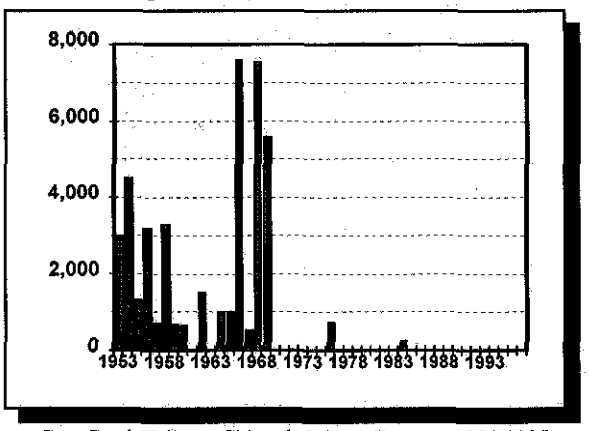


Cow Creek Streamflow, 1953-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

In the past, Cow Creek has supported eight small gravel mining operations. The lower 10 miles of channel is approximately 50% exposed bedrock. Where bedload is deposited, it is generally only a thin veneer. Instream mining was eliminated with the passage of a Shasta County gravel mining ordinance. There has been no instream gravel mining in Cow Creek for at least 12 years. Because of the limited availability of gravel, the bedload transport rate was estimated to be 19,000 tons per year.

Fall-run and late-fall-run chinook salmon spawn in the creek on the valley floor and in all five tributaries. Adult steelhead trout have been observed in South Cow, Old Cow, and North Cow Creeks. Previous management plans have estimated the potential of fall-run salmon in Cow Creek at 5,000 spawners; however, fall-run chinook salmon populations have been as high as 7,600. The average run size from 1953 to 1969 was 2,800 salmon. In recent drought years, there have been too few salmon in Cow Creek to make population estimates. No major diversions exist in the fall-run spawning reach, and the average monthly flow from October through December has actually increased since 1969. The decline in the Cow Creek fall-run salmon population coincides with salmon population declines throughout the Sacramento River basin. There are no estimates for late-fall-run chinook in Cow Creek.

In 1992, DFG conducted stream surveys of four of the five Cow Creek tributaries. Emphasis was placed on evaluating habitat for spring-run chinook salmon and steelhead trout holding, spawning, and rearing. The survey results concluded that Cow Creek is not suitable for spring-run chinook salmon because of warm summer water temperatures and lack of large holding pools. Steelhead, however, could survive if provided access to the tributaries above the valley floor. North Cow, Clover, and Old Cow Creeks have natural bedrock falls that are either complete or partial barriers to anadromous fish.



Cow Creek Fall-run Chinook Salmon Returns, 1954-1997.

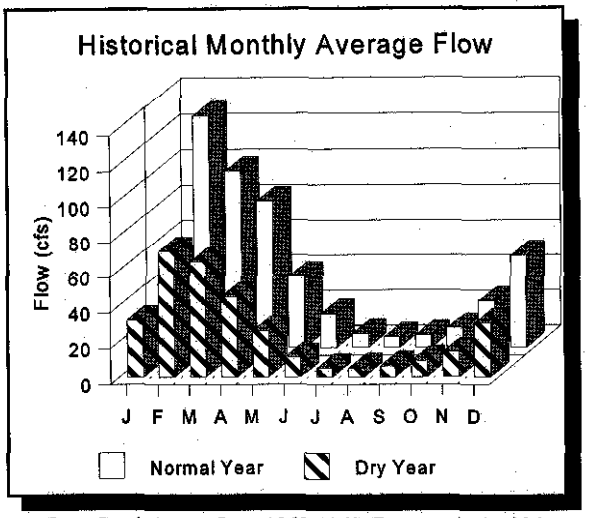
Land use activities in the Cow Creek drainage include agriculture, timber harvest, livestock grazing, and hydropower production. Loss of habitat and water diversions are largely the result of activities associated with livestock production. The only laddered dams and screened diversions are part of hydropower facilities. Agricultural diversions are unscreened, ditches are unlined and poorly maintained, and grazing is destroying some of the riparian corridor and causing excessive erosion.

Population growth in the towns of Palo Cedro, Bella Vista, Oak Run, and Millville is resulting in increased demand for domestic water and is affecting riparian habitat in the Cow Creek watershed. Measures are required to protect the existing habitat from further damage associated with gravel extractions, water diversions, creek-side development, and livestock grazing. Cow Creek presents a unique opportunity to maintain and preserve fall- and late-fall-run salmon and steelhead habitat while nearby development increases.

Bear Creek Ecological Management Unit

Bear Creek is a small, eastside tributary entering the Sacramento River 5 miles below Anderson. The stream has low streamflow in spring through fall months of most years and flows year round at the Highway 44 bridge in dry years. All steelhead habitat is above this bridge. During spring and summer, the limited natural streamflow is further reduced by irrigation diversions in the lower reaches, where the stream enters the valley floor. Adequate streamflows in fall and spring are prerequisites for anadromous fish migration and reproduction.

The limited runoff in this small stream makes it difficult to simultaneously meet the limited agricultural water demands and instream flow needs of anadromous fish, especially in below-normal water years. During above normal water years, there is a reduced risk to juvenile salmon and steelhead during the spring diversion season, because irrigation water demands are reduced and the diversion rates are relatively small compared to the total streamflow.



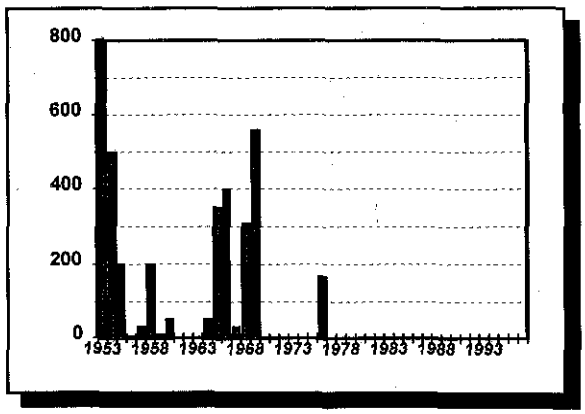
Bear Creek Streamflow, 1960-1967 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Bear Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate from foothills rather than the Cascade or Sierra crests. Near its mouth (where the gaging station is located) the stream is nearly dry during summer and fall months of low rainfall years. In wettest years, flows in winter months average 1,100 to 2,000 cfs. In winter months of dry years, average monthly flows reach only 30 to 70 cfs. In the driest years, winter monthly average flows reach only 20 to 35 cfs. Small agricultural diversions contribute to lower flows in summer and fall.

Bear Creek is able to support populations of fall-run chinook salmon only when early fall rains create suitable conditions for passage over shallow riffles and allow access to the limited spawning habitat. Because of low and warm streamflow conditions in spring, juvenile salmon and steelhead must emigrate early in the season to survive.

Salmon spawning surveys conducted during years with sufficient flows to attract adult salmon indicate that Bear Creek can support 150-300 spawning salmon. Steelhead have been observed in the creek, but no population estimates have been made.

Unscreened irrigation diversions operating during the juvenile emigration period for chinook salmon and steelhead can significantly reduce survival rates.



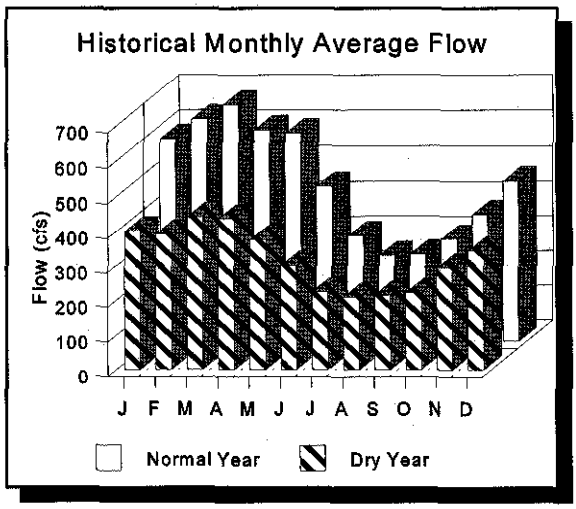
Bear Creek Fall-run Chinook Salmon Returns, 1943-1997.

BATTLE CREEK ECOLOGICAL MANAGEMENT UNIT

Battle Creek enters the Sacramento River approximately 5 miles southeast of the Shasta County town of Cottonwood. It flows into the Sacramento Valley from the east, draining a watershed of approximately 360 square miles.

Battle Creek has a natural flow pattern of high winter and moderate summer-fall flows, typical of Mount Shasta-Cascade spring-fed streams. Near its mouth (where the gaging station is located), the stream has average flows of 240 to 260 cfs in summer and fall. Even in the drier years, flows are more than 150 cfs. In wettest years, flows in winter months average 1,200 to 2,400 cfs. Battle Creek has the best connection between the river and mountainous areas of any Sacramento River ecological management unit. PG&E operated a series of small run-of-the-river hydroelectric diversions that divert up to 98% of the stream's baseflow and a much smaller portion of the wet season flow. Under and interim agreement, the required minimum fishery releases to the creek are increased by a factor of 10 at three diversions in a 17-mile section of the creek system.

PG&E owns and operates the Battle Creek project, which consists of two small storage reservoirs, four unscreened hydropower diversions on the North Fork Battle Creek, three unscreened hydropower diversions on South Fork Battle Creek, a complex system of canals and forebays, and five powerhouses.

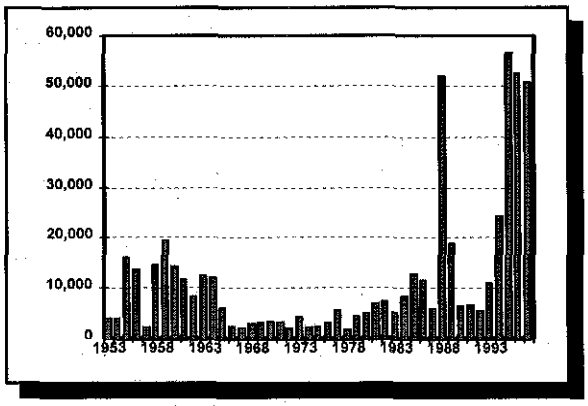


Battle Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

ERPP proposes to restore important ecological functions and processes and habitats in a step-by-step approach over several years. Restoration of these ecosystem elements will permit the restoration of anadromous fish in the basin. In addition, restoration will require disease management measures for the fish hatchery water supply. As the range of anadromous fish in the watershed is increased, additional efforts will be directed at fish screens, fish ladders, hatchery water supply management, and increased releases of water from hydroelectric diversions. The approach will first restore the stream reach capable of supporting all types of anadromous fish. This approach will restore approximately

one-half of the available anadromous fish habitat without subjecting the hatchery to increased disease risk or degrading the quality of the hatchery water supply.

Before development, Battle Creek was one of the most important chinook salmon spawning streams in the Sacramento Valley. Runs of fall-, winter-, and spring-run chinook salmon and steelhead were found there. Natural spawning of salmon and steelhead in Battle Creek between the Coleman National Fish Hatchery weir and the mouth is still significant but suffers from spawning populations too large for available habitat. The blockage of the fall-run chinook salmon migration at the hatchery and the effect of low flows caused by PG&E's hydropower operations have combined to reduce salmon and steelhead populations above the hatchery to remnant status.



Battle Creek Fall-run Chinook Returns, 1953-1997.

There is one large, unscreened agricultural diversion (Battle Creek Diversion). DFG constructed a screen for this diversion, but because of landowner concerns, installation of the screen was delayed. The screen has recently been installed.

Restoring the remnant populations of naturally spawning chinook salmon and steelhead located above the fish hatchery barrier dam to a healthy status can be done in a manner that integrates the beneficial uses of hydropower production and aquaculture in the watershed. Physical and operational changes of PG&E's projects include screening or removing the diversions on the North Fork and South Fork of Battle Creek, increasing releases from project diversions, and stopping removal of stream gravel that accumulates at project diversions.

Anadromous fish have historically migrated above the hatchery during minor and major storm events each year which flood out the hatchery barrier dam and when the fish ladder at the barrier dam has been opened for four to five months during past years. The Coleman Hatchery Development Plan proposes a phased installation of an ozone sterilization system. The present level of ozonation at Coleman Hatchery (10,000 g.p.m.) is sufficient to sterilize all the water needed to produce the early life stages of chinook salmon and steelhead and one-third of the water necessary to produce juvenile fish. The environmental documents and preliminary funding arrangements have been completed to begin the construction of the remaining two-thirds of the water supply needed for juvenile fish production.

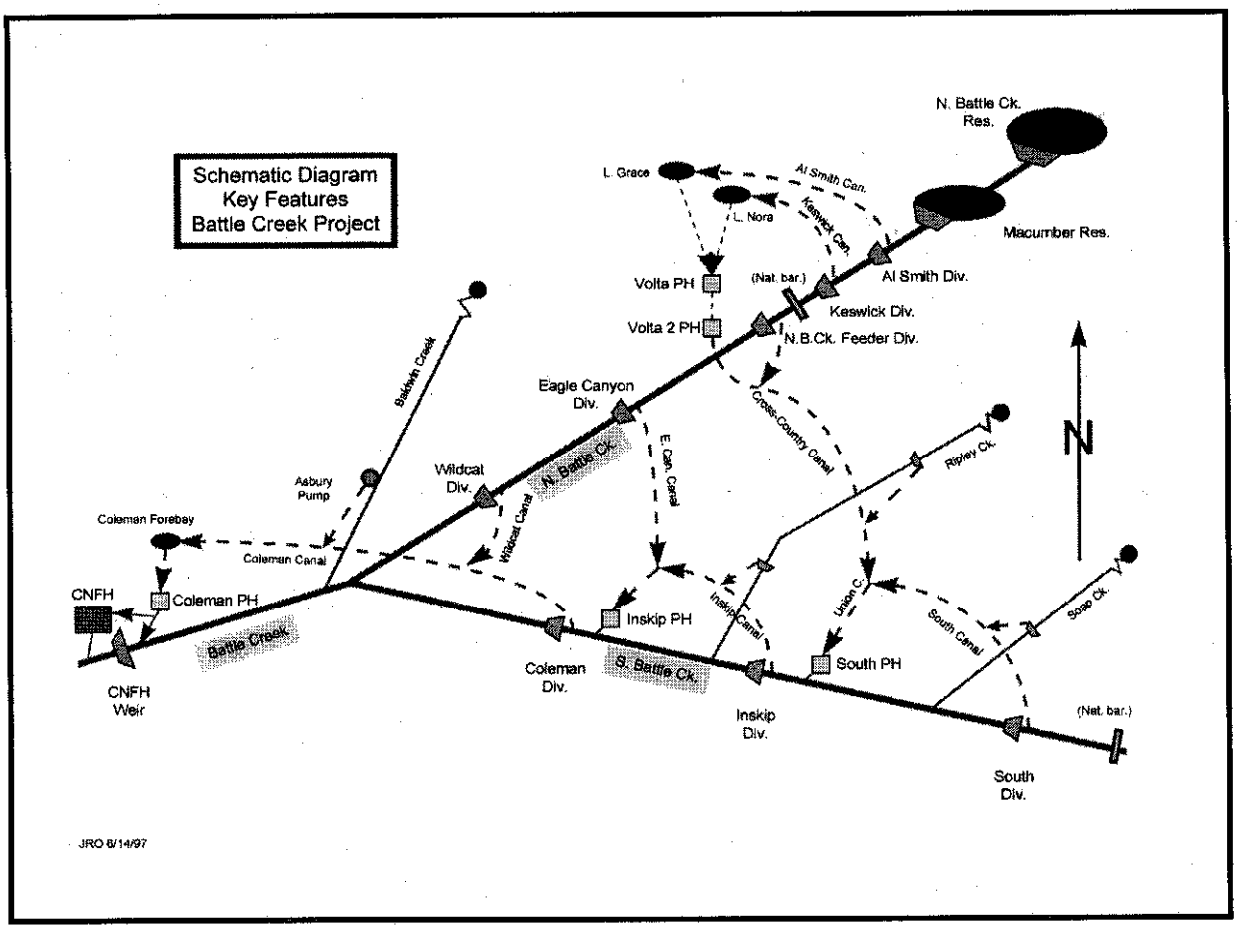
The restoration of naturally produced runs of anadromous fish in Battle Creek can be conducted in a manner compatible with the phasing in of the ozone treatment plant. If those races of salmon that represent a significant disease risk are restricted through seasonal fish ladder closures to the first 17-mile reach of Battle Creek above the hatchery for the initial phase of restoration, a hatchery water supply can be maintained and the capacity to supply the balance of the hatchery water supply that will not be treated with ozone can be reached. It will be necessary to improve the reliability of the Coleman Canal water supply.

The fish hatchery, located approximately 6 miles upstream of the mouth of Battle Creek, is operated by the U.S. Fish and Wildlife Service (USFWS). It was constructed by Reclamation as partial mitigation for the construction of Shasta Dam and produces fall-run chinook salmon, late-fall-run chinook salmon, and steelhead trout. Winter-run chinook salmon, a federally and State-listed endangered species, was also successfully

propagated in small numbers at the hatchery to supplement the wild population. The winter-run chinook artificial propagation program at Coleman was stopped and is in the process of being moved to a new facility at the base of Shasta Dam. This is scheduled to be operational in early 1998.

Restoration of Battle Creek's anadromous fish habitat above the valley floor will focus on restoring spring-run chinook salmon and steelhead trout. These actions will be sufficient to provide for the requirements of winter-run chinook salmon that may return to Battle Creek.

Surveys conducted before the construction of Shasta Dam indicate that, with sufficient water, the stream reaches above the fish hatchery could provide spawning habitat for more than 1,800 pairs of salmon. The stream reaches up to MacCumber Dam are not reachable by anadromous fish because of barriers. The anadromous reach in the North Fork Battle Creek extends up to approximately two miles above the North Fork Battle Feeder Dam. The recent (1991) evaluation of spawning habitat in the portions of Battle Creek watershed accessible to anadromous fish above Coleman Hatchery Fish Barrier estimate 166,000 square feet of spawning gravel. Potentially, this much spawning habitat could accommodate 3,500 spawning pair. The North Fork of Battle Creek, Eagle Canyon in particular, contains deep, cold, and isolated pools ideal for holding spring-run chinook salmon throughout summer. Because of the critically low numbers of spring-run chinook salmon and steelhead in the Sacramento River drainage, any expansion of available habitat for these fish has a high priority.



From 1985 through 1989, adult fall-run chinook salmon, surplus to the fish hatchery egg-taking needs, were released into Battle Creek above the hatchery weir to spawn naturally. Because of potential disease problems at the hatchery related to decomposing carcasses, the fish ladders on PG&E's two lowermost diversions (Wildcat Diversion on the North Fork and Coleman on the South Fork) were closed. This action prevented fish from ascending into the area above the hatchery water supply intake and eliminated the possibility of salmon migrating into the middle or upper reaches of those streams.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the North Sacramento Ecological Management Zone is to restore important fishery, wildlife, and plant communities to a healthy condition. To attain this vision, the Ecosystem Restoration Program Plan recommends developing and implementing comprehensive watershed management plans for the streams in this zone, which will restore important ecological processes that create and maintain habitats for fish, wildlife, and plant communities.

The vision focuses on restoring spring-run chinook salmon and steelhead to population levels of the late 1960s and early 1970s. To achieve this vision, ERPP recommends increased protection for naturally produced chinook salmon and steelhead as they rear and migrate downstream from the natal areas to the mainstem Sacramento River. This would involve improving passage at water diversion structures; installing positive-barrier fish screens to protect juveniles; and providing sufficient flows for migration, holding, spawning, and rearing.

Gravel extraction is a significant problem in many areas of this ecological management zone, and a cooperative effort is needed to relocate this activity to sites away from the active stream channels. ERPP also recommends reestablishing floodplains in the lower stream reaches to allow stream channel meander, sediment transport and deposition, and a healthy riparian corridor. Actions to maintain and restore healthy riparian zones include providing shaded riverine aquatic habitat and woody debris and maintaining biologically productive gravel beds for fish spawning and invertebrate production.

ERPP envisions that the fish, wildlife, and riparian needs of the North Sacramento Valley Ecological Management Zone will be met and an acceptable level of ecosystem health will be achieved when the following visions have been satisfactorily attained.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

CLEAR CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Clear Creek Ecological Management Unit is to restore flows from Whiskeytown Dam to allow successful upstream passage of chinook salmon and steelhead to historical habitat, restore sediment transport and gravel recruitment in the stream channel, and establish a clearly defined stream meander zone, and riparian and riverine aquatic plant communities.

The potential of providing sustainable and resilient ecological processes and habitats will be enhanced by developing a locally sponsored watershed management planning process for this unit.

CLEAR CREEK WATERSHED DEMONSTRATION PROGRAM: Clear Creek has tentatively been selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support and bolster ongoing efforts to implement a successful management and rehabilitation effort within this watershed so that

lessons learned in this watershed can be applied to similar watersheds.

Clear Creek has some interesting attributes that have contributed to its selection.

- The upper watershed is in mixed private and federal ownership and is included in the President's Northwest Forest Planning effort.
- The watershed is addressed by the Northwest Sacramento Province Advisory Committee comprised of representatives of federal agencies such as the U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management and others.
- Streamflows in Clear Creek below Whiskeytown Dam are controlled largely by the U.S. Bureau of Reclamation.
- Restoration of Clear Creek is specified in the Central Valley Project Improvement Act.
- Clear Creek supports chinook salmon and with restoration could support spring-run chinook salmon and steelhead.
- Strong local interest in the watershed.
- Many ongoing restoration activities and efforts such as land acquisition, water acquisition, and passage improvement.

Cumulatively, an investment in Clear Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Clear Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how to best manage ecological processes such as sediment transport and stream meander in a highly modified stream system.

Cow Creek Ecological Management Unit

The vision for the Cow Creek Ecological Unit includes reducing adverse effects of timber harvest, erosion, and cattle grazing on the stream and riparian system and maintaining or restoring streamflows during important periods of the year to allow fish migration, spawning, and rearing of fall-run chinook salmon and steelhead trout. A comprehensive watershed management plan developed and implemented at the local level would assist in restoring this creek. In addition, sediment in the creek is limited, and ERPP recommends a cooperative program to relocate gravel extraction operations to areas outside the active stream channel.

Actions on Cow Creek include obtaining flow agreements, screening diversions to protect all life stages of anadromous fish, improving fish passage at agricultural diversion structures, and fencing selected riparian corridors in the watershed to exclude livestock and promote riparian regeneration.

Bear Creek Ecological Management Unit

The vision for the Bear Creek Ecological Management Unit will emphasize restoring and maintaining important ecological processes, such as streamflow and sediment supply. Steelhead trout is an important species that will benefit from improvements related to fish passage and immigration and holding, spawning, and rearing habitats. The individual value of Bear Creek is small, but, cumulatively, the values of streams such as this can be integral and valuable in restoring ecological health to the Bay-Delta system, particularly for the steelhead trout and fall-run chinook salmon resources. Recent, but limited field studies, have shown that in some

years lower Bear Creek can provide valuable non-natal rearing habitat for juvenile salmonids.

ERPP recommends a cooperative program with water users for a mutually acceptable flow schedule that would not only provide protection for downstream migrating salmon and steelhead but recognize the needs of agriculture. This could be accomplished through conjunctive use of groundwater.

BATTLE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Battle Creek Ecological Management Unit includes support for a local watershed conservancy and developing and implementing a comprehensive watershed management plan, increasing flows, improving the water supply to Coleman National Fish Hatchery, removing diversion dams or installing new ladders, and installing positive-barrier fish screens to protect juvenile chinook salmon and steelhead.

Improving water management operations and installing positive-barrier fish screens will provide large benefits to many aspects of the ecological processes and fish and wildlife in the watershed. ERPP also envisions that Battle Creek will provide much-needed habitat for steelhead trout and spring-run chinook salmon, in addition to maintaining its existing importance to fall- and late-fall-run chinook.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: Healthy instream flows are sustained to restore ecological processes and functions that maintain habitats and support aquatic species. Streamflows shape channels, support riparian vegetation, provide habitat for fish, and transport young fish downstream. Healthy streamflow patterns in the streams tributary to the upper reach of the Sacramento River below Keswick Dam would emulate natural flow patterns, with late-winter/early-spring flow events and sustained flow well into the summer. The vision is that streamflow will be provided at levels that activate ecological processes that shape the stream channels and sustain riparian and riverine aquatic habitat, transport sediments, and sustain juvenile anadromous fish during the summer.

COARSE SEDIMENT SUPPLY: The supply of sediments to the streams in the North Sacramento Valley Ecological Management Zone support stream channel maintenance and sustain riparian and riverine aquatic habitats. This sediment includes gravel for fish spawning and invertebrate production The vision is that processes to provide a continual supply of coarse sediments will be restored, reactivated, or supplemented.

STREAM MEANDER: Streams in the North Sacramento Valley Ecological Management Zone exhibit a natural tendency to meander. This provides for the continual supply of coarse sediments, regeneration of the riparian corridor, and the rejuvenation of gravels used for fish spawning and invertebrate production. The vision is that stream meander corridors will be established or maintained to provide much of the needed sediments and habitats for fish, wildlife, and plant communities.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: River-floodplain interactions are important ecological events that occur at varying intervals, ranging from annual inundation of some of the floodplain to flow or flood events that inundate most of the floodplain. The larger events occur within 5-, 10-, 50-year or longer intervals. This recurrent flood cycle maintains the stream channel, allows the stream to contact higher gravel terraces, supports riparian regeneration, and allows the stream channel to migrate. The vision is that the floodplains of streams in the North Sacramento Valley Ecological Management Zone will be maintained at levels that permit recurrent floodplain inundation.

CENTRAL VALLEY STREAM TEMPERATURES: Chinook salmon and steelhead are dependent on specific stream temperatures. Optimum spawning and egg incubation typically occurs at 52°F while optimum rearing temperatures are slightly higher. Temperature requirements also vary among chinook runs, species, and life stage. The vision for stream temperatures is to provide sufficient flows to sustain cool water during important life stages to support all life stages of chinook salmon, steelhead, and other aquatic organisms.

VISION FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC: Riparian and riverine aquatic habitats support a wide diversity of aquatic and terrestrial species. Healthy riparian corridors provide a migratory pathway between lower and higher elevation habitats for terrestrial species, such as mammals and birds. Shaded riverine aquatic habitat provides important habitat complexity in the stream, which includes shade and escape cover for juvenile fish. The vision for riparian and riverine aquatic habitat is that riparian corridors will be maintain and restored by improvements in sediment transport, stream meander, reconnecting streams with their floodplains, improved grazing and other land use practices, and by the creation of extensive riparian protection zones.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper sections of these creeks are typical of salmon-steelhead streams while the lower sections are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The vision is that the quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Clear, Cow, Bear, and Battle creeks have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is for EFH is to maintain or restore substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSION: Water diversions reduce the quantity of flow below the diversion point and cause direct mortality by entraining young fish. The vision for water diversion and unscreened diversion in the North Sacramento Valley Ecological Management Zone is that sufficient flow will remain below diversion points to permit the successful up- and downstream migration of adult and juvenile fish, and that water will be diverted through state-of-the-art positive barrier fish screens to reduce loss of juvenile fish.

DAMS AND OTHER STRUCTURES: Instream structures frequently impair the upstream and downstream passage of anadromous fish. The vision for the North Sacramento Valley Ecological Management Zone is that the connections between upstream holding, spawning, rearing, and migration habitats and the Sacramento River will be reestablished, improved, maintained, and reestablished on some streams to permit unobstructed fish passage.

GRAVEL MINING: Gravel mining can greatly reduce the quality and quantity of coarse sediments in the streams of the North Sacramento Valley Ecological Management Zone. The vision is that gravel mining operations in the active stream channel will be reduced and relocated to alluvial deposits outside the active stream channel.

INVASIVE RIPARIAN AND MARSH PLANTS: Invasive riparian plants can outcompete and displace native vegetation. Often, these invasive plants have little or no value to native fish or wildlife species. The vision for reducing invasive riparian plants in the North Sacramento Valley Ecological Management Zone is to establish cooperative and coordinated eradication programs that allow the regeneration of native plant species and communities.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead can reduce the number of spawning fish and impair other efforts to restore and rebuild spawning populations. The vision for illegal harvest in the North Sacramento Valley Ecological Management Zone is to implement a stronger enforcement and public education program. The vision for legal harvest is to develop harvest strategies that assist in the restoration of anadromous fish species.

ARTIFICIAL PROPAGATION OF FISH: The production of chinook salmon and steelhead at Coleman National Fish Hatchery on Battle Creek supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from the construction of Shasta Dam. Due to release practices, hatchery fish from Battle Creek and other Central Valley hatcheries supplement the numbers of naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers. The vision for artificial production in the North Sacramento Valley Ecological Management Zone is to implement hatchery practices that contribute to the recovery of naturally spawning populations of salmon and steelhead.

VISIONS FOR SPECIES

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook is to recover this State-listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook are dependent on late-winter/early-spring flows for upstream passage, deep pools and cool water for oversummer survival, and quality gravel for successful spawning in the fall. The vision for spring-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

FALL-RUN CHINOOK SALMON: The vision for the fall-run chinook salmon is to recover all stocks proposed for listing under ESA. Fall-run chinook depend on late-summer and fall streamflow for access to spawning areas in the lower stream reaches. Habitat suitability is influenced by water temperatures. The vision for fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support spawning and juvenile rearing through late spring.

LATE-FALL-RUN CHINOOK SALMON: The vision for late-fall-run chinook salmon is to recover this run proposed for listing under the ESA. Late-fall-run chinook typically depend on winter stream flows and quality spawning gravel. The vision for late-fall-run chinook salmon in the North Sacramento Valley Ecological Management Zone is to improve ecological processes that create and maintain spawning habitat and reduce sources of mortality that diminish survival of juvenile and adult fish.

STEELHEAD: The vision for Central Valley steelhead is to recover this federally listed

threatened species and achieve naturally spawning populations of sufficient size to support inland recreational fishing at that use fully existing and restored habitats. Juvenile steelhead are dependent on cool water for oversummer survival, late-winter/early-spring flows for downstream passage, and quality gravel for successful spawning in the late winter/early spring. The vision for steelhead in the North Sacramento Valley Ecological Management Zone is that stream flows, stream temperatures, and habitat quality will be maintained or restored to a level that will support adult and juvenile populations.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors in the North Sacramento Valley Ecological Management Zone which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

LOCAL WATERSHED PLANNING GROUPS

Maintaining and restoring the ecological health of the ecological units in the North Sacramento Valley Ecological Management Zone will depend heavily on local watershed groups, including local landowners, concerned individuals, and local resource experts. The only formal watershed planning group in this Ecological Management Zone is the Clear Creek Coordinated Resources Management Program (ARMP) fostered by the Western Shasta Resource Conservation District. A Battle Creek watershed interest group is forming but has not developed a formal approach to watershed planning. Additional groups are needed to sponsor watershed planning and restoration on Cow and Bear Creeks.

Ecosystem restoration efforts in the North Sacramento Valley Ecological Management Zone will be linked to cooperation from resource agencies, such as DFG, DWR, USFWS, and the National Marine Fisheries Service (NMFS), as well as participation and support from Reclamation, the U.S. Natural Resources Conservation Service, and private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce the impacts of diversions, and

minimize poaching and habitat and water quality degradation in basin streams. In support of this effort, cooperating agencies should seek funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction. The vision will help DFG as it progresses toward doubling the number of anadromous fish over the number present in 1988.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The U.S. Fish and Wildlife Service and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment, fish passage, water temperature control in the reach between Keswick Dam and the Red Bluff Diversion Dam (RBDD), water acquisition, and other measures that will contribute to health of the Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

The vision for the North Sacramento Valley Ecological Management Zone will contribute to and benefit from the Anadromous Fish Restoration Program (AFRP), which strives to double the natural production of anadromous fish in the system over the average production from 1967 through 1991.

Reclamation is willing to assist in restoring Clear Creek fish habitat by providing additional water from Whiskeytown Reservoir. The amount of water committed to maintain salmon and steelhead in this creek is presently recommended not to exceed 200 cfs from October 1 through June 1 and 150 cfs from June 2 to September 30. Flows are being evaluated to determine the instream flow necessary to achieve the strategic objective. Because passage and McCormick-Saeltzer Dam has not yet been achieved, AFRP recommended flows have not been implemented for Clear Creek (USBR and DWR 1999).

CALFED BAY-DELTA PROGRAM

CALFED has funded eight ecosystem restoration projects in the North Sacramento Valley. Most projects improve fish passage. One project improves fish passage on Clear Creek by removing McCormick Seltzer Dam. The most significant project in the Zone will re-open 42 miles of fish habitat on Battle Creek by removing five diversion dams and laddering and screening another three dams.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The North Sacramento Valley Ecological Management Zone is most closely linked to the Sacramento River Ecological Management Zone and exhibits a high degree of connectivity through the confluences of Clear, Cow, Bear, and Battle creeks with the Sacramento River Ecological Management Zone.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

PROGRAMMATIC TARGET: More closely emulate the seasonal streamflow patterns in Clear, Cow, and Battle Creeks in most year types by providing or maintaining flows that mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession.

TARGET 1: Increase flow in Cow Creek by 25 to 50 cfs, corresponding to the natural seasonal runoff pattern, and maintain 25 to 75 cfs during October (◆◆).

PROGRAMMATIC ACTION 1A: Increase flow in Cow Creek by purchasing water from willing sellers or implementing a conjunctive groundwater program.

TARGET 2: Increase flow in Clear Creek to 150 to 200 cfs from October 1 to May 31 and to 100 to 150 cfs from June 1 to September 30 (◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve flow in Clear Creek by increasing releases from Clair Hill Whiskeytown Dams.

TARGET 3: Augment flow in Battle Creek by 25 to 50 cfs (◆◆).

PROGRAMMATIC ACTION 3A: Increase flow in Battle Creek by purchasing water from willing sellers or providing compensation for forgone power production. This includes negotiating and renewing an existing interim flow agreement between the Department of the Interior and PG&E, and includes a provision for the release of 10 cfs at the Asbury Pump on Baldwin Creek, a dewatered Battle Creek tributary that provides steelhead habitat. In the longer-term, this action also include increasing flows at the Inskip Diversion Dam and South Diversion Dam.

TARGET 4: Augment flow in Bear Creek by 10 to 20 cfs (◆).

PROGRAMMATIC ACTION 4A: Increase Bear Creek flow by purchasing water from willing sellers or providing alternative sources of water to diverters during important fish passage periods in spring and fall.

RATIONALE: *The streams in the North Sacramento Valley Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this ecological zone is providing for successful upstream passage of adult fish. Water is diverted from the streams in this zone during periods that impair upstream passage conditions and prevent fish from reaching important oversummering or spawning habitats. Acquiring water from willing sellers and implementing programs to provide alternative sources of water during important periods are direct approaches to solving this problem. For example, natural flow in Bear Creek is often less than the combined water rights of diverters, resulting in total dewatering of the creek in the valley reach during critical periods for chinook salmon.*

The recommended AFRP flows for Clear Creek, as specified in Target 2, should be implemented immediately. Because steelhead and spring-run chinook salmon do not have access to the better quality habitat upstream of McCormick-Saeltzer Dam, it is all the more imperative that adequate flows be provided to restore some conditions in the reach immediately below McCormick-Saeltzer Dam.

CENTRAL VALLEY STREAM TEMPERATURES

TARGET 1: Maintain suitable water temperatures in Clear Creek for spring-run chinook and steelhead holding, spawning, and rearing (◆◆◆).

PROGRAMMATIC ACTION 1A: Maintain 56° F to approximately 3 miles downstream of McCormick-Saeltzer Dam from June through September.

RATIONALE: *Whiskeytown Dam provides an excellent opportunity to provide cold water releases from the lower depths of the reservoir to maintain adequate temperatures in downstream reaches. Because salmon and steelhead cannot access the higher quality habitat in Clear Creek because of the blockage at McCormick-Saeltzer Dam, greater releases will need to be made from Whiskeytown Dam to provide adequate temperatures in the reach below McCormick-Saeltzer Dam. Preliminary results from an ongoing temperature modeling study indicate that the AFRP recommended flows have the potential to provide adequate temperatures for spring-run chinook and steelhead in most of the reach between Whiskeytown and McCormick-Saeltzer dams. However, higher releases are necessary to achieve adequate temperatures below McCormick-Saeltzer Dam, and should be provided until McCormick-Saeltzer Dam is removed or modified to allow passage.*

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain existing levels of erosion and gravel recruitment in streams of the North Sacramento Valley Ecological Unit and, where necessary, supplement gravel recruitment through adaptive management and monitoring (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively develop appropriate land use plans that allow the natural recruitment of sediments to streams in the North Sacramento Valley Ecological Management Zone.

TARGET 2: Increase existing levels of erosion and gravel recruitment in Clear Creek by 25 to 50 tons per year (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve gravel quality and quantity in lower Clear Creek to maintain high-quality spawning conditions for fall-run and late-fall-run chinook salmon by evaluating the addition of 5,000 to 10,000 cubic yards annually as needed. Evaluate the need to acquire or relocate existing mining operations. Alter McCormick Dam so that it no longer serves as a sediment trap.

TARGET 3: Increase existing levels of erosion and gravel recruitment in Cow Creek by 5 to 10 tons per year (◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to protect existing gravel and bedload movement in Cow Creek to maintain and increase future spawning gravel and sediment input to the Sacramento River by 5 to 10 tons per year by evaluating the need or opportunity to acquire or relocate existing gravel mining operations.

RATIONALE: *Replenishing gravel supplies to a level sufficient to support target populations of salmon and steelhead will help to improve populations to desirable levels and to maintain such levels once achieved. Replenishing gravels to maintain channel-forming processes and stream meanders will help to maintain fish and wildlife habitats, aquatic algae and invertebrate production, and streamside vegetation (California Department of Water Resources 1980). A predevelopment level of gravel recruitment should be adequate to restore the natural ecological processes supported by gravel recruitment, but may require experimenting, monitoring, and experience to determine the exact amount of gravel supplies necessary to meet the objective. Sediment supplementation programs, particularly in Clear Creek, need to be integrated with downstream channel forming processes, which will be subject to adaptive management, as well as*

to a different set of indicators, monitoring, and focused research.

Rivers with a natural shape and hydrologic condition generally support the most diverse mixture of habitats and fish and wildlife species and are the most resilient to natural or human disturbance.

STREAM MEANDER

PROGRAMMATIC TARGET: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of Clear Creek, particularly in low-gradient areas where most sediment deposition occurs and where stream channel meander is most pronounced.

TARGET 1: Create a more defined stream channel in the lower 8 miles of Clear Creek to facilitate fish passage (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to improve lower Clear Creek by maintaining flow connection with the Sacramento River and by regrading the channel and controlling vegetative encroachment.

RATIONALE: *Gravel deposits in Clear and Cow Creeks are essential to maintaining spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Whiskeytown Dam and extensive gravel extraction in the lower section of Clear Creek continue to reduce the amount of gravel transport to near zero; Cow Creek has only a limited natural supply and has been adversely affected by gravel mining in its lower reach near the Sacramento River. Although small, Cow Creek provides an important source of sediments to the Sacramento River, particularly for the 8- to 10-mile reach between its confluence with the river and the mouth of Cottonwood Creek.*

The Clear Creek stream meander belt is the area in which natural bank erosion and floodplain and sediment bar accretions occur. Natural stream meander belts in alluvial systems function dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish, as well as surfaces that are colonized by natural vegetation that support wildlife. The flow regime in Clear Creek has recently been improved by adding supplemental water under provisions of the CVPIA. This improved flow will assist in reactivating or reestablishing the natural stream channel. Because of low flow releases from Whiskeytown Lake in the past, vegetation has encroached into the lower 3 miles of the active stream channel on Clear Creek, prevented meander, and fixed stream sediments so that they no longer contribute to sediment load or provide substrate for fish spawning.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Increase and maintain the Clear Creek floodplain in conjunction with stream meander corridor restoration (◆◆◆).

PROGRAMMATIC ACTIONS 1A: Develop a cooperative program, consistent with flood control requirements, to evaluate the feasibility of altering stream channel configuration in the lower reach of Clear Creek to increase the areal extent of floodplains inundated during high flow periods.

TARGET 2: Reestablish natural floodplain and stream channel meander in the lower 8 miles of Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire floodplains by direct purchase or easement from willing sellers.

RATIONALE: *Floodplain inundation is a secondary ecosystem process related to water and sediment flow through the Sacramento-San Joaquin Basin in combination with geomorphology. Floodplain inundation is the seasonal flooding of floodplain habitats, including riparian and riverine aquatic habitats. Flooding*

of these lands provides important seasonal habitat for fish and wildlife and provides sediment and nutrients to both the flooded lands and aquatic habitats that receive the returning or abating floodwater. The flooding also shapes the plant and animal communities in the riparian, wetland, and upland areas subject to flooding. Opportunities to restore or enhance this process are possible by changing landscape features, geomorphology, and seasonal distribution of flow volume through the system.

HABITATS

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish riparian habitat zones along streams in the North Sacramento Valley Ecological Management Zone through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Clear Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to further improve water temperatures. Develop a cooperative approach with counties and local agencies to implement land use management that protects riparian vegetation along the streams and develop programs to restore lost riparian vegetation

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cow, Bear, and Battle Creeks.

RATIONALE: *Many species of fish and wildlife in the North Sacramento Valley Ecological Management Zone depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in the Ecological Management Zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

ELIMINATING OR REDUCING STRESSORS

WATER DIVERSIONS

TARGET 1: Reduce or eliminate conflicts between the diversion of water and chinook

salmon and steelhead populations at all diversion sites on Battle Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative approach to improve conditions for anadromous fish in Battle Creek by installing fish screens at diversions on the North Fork, three diversions on the South Fork, and one diversion on the mainstem, or acquire water rights to eliminate the need for diversion and screening.

PROGRAMMATIC ACTION 1B: Improve the survival of adult salmon and steelhead in Battle Creek by installing a rack at the head of Gover Diversion Canal to prevent straying.

TARGET 2: Reduce or eliminate conflicts between the diversion of water and chinook salmon and steelhead populations at all diversions on Clear Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Acquire water rights on Clear Creek at the McCormick Dam to eliminate the need for diversion.

RATIONALE: *Diversion, storage, and release of water in the Clear and Battle Creek watersheds directly affect fish and other aquatic organisms and indirectly affect habitat, foodweb production, and species abundance and distribution. Diversions cause consumptive loss of water, nutrients, sediment, and organisms. Seasonal and daily patterns of water released from storage may affect habitat, water quality, and aquatic organism survival. In both Clear and Battle Creeks, water diversion and water diversion structures have caused direct mortality by removing juvenile fish from the population. Water diversion also reduces the quantity and quality of stream habitats and the resiliency of fish populations. Where possible, it is more desirable to acquire water rights and eliminate the diversion than to install positive-barrier fish screens.*

Coleman National Fish Hatchery receives its water supply directly from Battle Creek. Because of past incidences of disease at the hatchery, adult salmon and steelhead were blocked from ascending the creek to prevent disease contamination of the hatchery water supply. Restoring naturally spawning fish in the upper watershed will be limited until water can be supplied to the hatchery in a manner that will not contribute to disease outbreaks.

DAMS AND OTHER STRUCTURES

PROGRAMMATIC TARGET: Eliminate or reduce water uses that conflict with increasing the success of spawning adults and survival of juvenile chinook salmon and steelhead by managing or reconstructing facilities and structures that impair fish passage and fish survival.

TARGET 1: Work with landowners and diverters on Cow Creek to reduce the adverse effects of 13 seasonal diversion dams in South Cow Creek, 10 diversion dams in Old Cow Creek, two diversion dams in North Cow Creek, and one diversion dam in Clover Creek that are barriers to migrating chinook salmon and steelhead. This would allow access to 100% of the habitat below any natural bedrock falls (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve passage conditions on Cow Creek by acquiring water rights from willing sellers, removing diversions, or providing alternative sources of water during important periods.

TARGET 2: Work with landowners and diverters on Bear Creek to reduce the adverse effects of dewatering the stream channel at seasonal diversion dams, which results in no passage for migrating chinook salmon (◆◆◆).

PROGRAMMATIC ACTION 2A: Improve passage and habitat conditions in Bear Creek by acquiring water rights from willing sellers, evaluating the removal of diversion dams, or providing alternative sources of water during important periods.

TARGET 3: Work with landowners, diverters, and other state or federal agencies managing Battle Creek to improve fish passage (◆◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to upgrade or replace existing fish ladders or evaluate the removal of diversion dams and other impediments to passage.

TARGET 4: Work with landowners and diverters on Clear Creek to improve fish passage between its mouth and Whiskeytown Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative program to improve fish passage on Clear Creek by upgrading or replacing the fish ladder at McCormick-Saeltzer Dam or removing or modifying the dam..

TARGET 5: Reduce or eliminate conflicts in Battle Creek that require excluding anadromous fish from the upper section to protect the Coleman National Fish Hatchery water supply (◆◆◆).

PROGRAMMATIC ACTION 5A: Develop an alternative or disease-free water supply for Coleman National Fish Hatchery to allow naturally spawning salmon and steelhead access to the full 41-mile reach of Battle Creek above the Coleman National Fish Hatchery weir.

TARGET 6: Investigate possibility of providing access for steelhead to streams above Whiskeytown Dam (◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program to investigate the feasibility/desirability of providing access to tributaries above Whiskeytown Dam.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Fish passage in the North Sacramento Valley Ecological Management Zone is impaired in Clear, Cow, Bear, and Battle Creeks by a variety of permanent and seasonal dams used to divert water for irrigation or power production. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern, such as spring-run chinook salmon and steelhead, as well as the other stocks of chinook salmon. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn in good health, which will increase their chances of successfully spawning. Improved fish passage will allow anadromous fish to reach the habitat they require to oversummer or to spawn and rear in good health, which will increase their chances of successful spawning.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow wild, naturally produced fish spawning populations to attain levels that fully use existing and restored habitat, and focus harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Continue the mass-marking program and selective harvest regulations for hatchery steelhead.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining populations of chinook salmon and steelhead to levels that fully take advantage of habitat may require restricting harvest during and even after*

the recovery period. Involving the various stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may be such that existing harvest levels of wild, naturally produced fish cannot be sustained. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the harvest of wild fish, while hatchery fish are harvested at a level to reduce their potential to disrupt the genetic integrity of wild populations.

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams, thereby protecting naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if populations of salmon or steelhead can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment populations of fall chinook salmon and steelhead only when alternative measures are deemed insufficient to provide recovery of the populations.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced stocks of chinook salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the adult population available to the hatchery.

RATIONALE: *In watersheds such as the Sacramento River and Battle Creek, where dams and habitat degradation have limited natural spawning, hatchery supplementation may be necessary. This would sustain fishery harvest at former levels and maintain a wild or naturally spawning population during adverse conditions, such as droughts. Hatchery augmentation, however, should be limited so as not to inhibit recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, chinook salmon and steelhead stocking may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

STEELHEAD TROUT

SUPPLEMENTAL TARGET 1: Investigate the feasibility of using native rainbow trout currently isolated above dams to rebuild or recreate a steelhead run.

PROGRAMMATIC ACTION 1A: Conduct a comprehensive, basin-wide genetic evaluation of Central Valley steelhead stocks that includes analysis of self-sustaining populations of rainbow trout isolated above dams for purposes of identifying a suitable broodstock.

PROGRAMMATIC ACTION 2A: Conduct hatchery/ release investigations to determine if progeny of native resident rainbow trout raised in a hatchery will emigrate to the ocean.

RATIONALE: *Resident rainbow trout and anadromous steelhead likely comprise a single, interbreeding population in specific stream systems (IEP Steelhead Project Work Team 1999)*

. Native, resident rainbow trout presently isolated above dams could possess the genetic traits that would allow their use as an experimental broodstock to restore steelhead.. Planned and ongoing genetic analyses, conducted through the Comprehensive Central Valley Steelhead Genetic Evaluation (see ERPP Vol. 1, Species Vision for Steelhead Trout) and the Fish and Wildlife Service Upper Sacramento River Rainbow Trout Genetic Analysis, should be able to elucidate genetic relationships of resident and anadromous rainbow trout. If it is determined that native populations exist, experiments could be undertaken to determine if anadromous steelhead could be derived from an experimental hatchery population. If this is successful, then restoration of some stocks of native Central Valley steelhead thought to be extinct may be achievable through this method.

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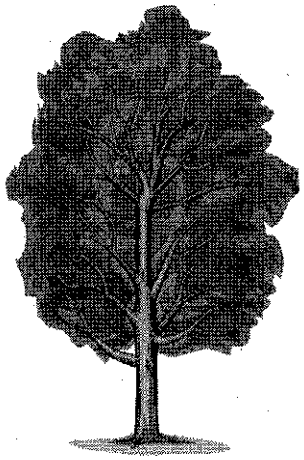
◆ COTTONWOOD CREEK ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

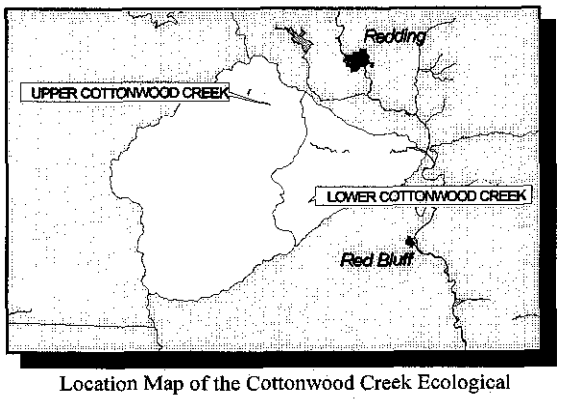
The health of the Sacramento-San Joaquin Delta is influenced by the interdependence and connectivity of the component ecosystem elements, particularly the 14 ecological management zones. The Cottonwood Creek Ecological Management Zone is located many miles from the Delta, but its status and health are ultimately reflected in the health of the Delta. The intermediate zone between the Delta and Cottonwood Creek is the Sacramento River. The Sacramento River Ecological Management Zone and its respective habitats and fish, wildlife, and plant assemblages depend on Cottonwood Creek, primarily for its ability to supply sediments and gravel to the river, but also for its seasonal contributions of flow.

DESCRIPTION OF THE MANAGEMENT ZONE

Cottonwood Creek drains an area of 930 square miles on the west side of the Central Valley and enters the Sacramento River a short distance downstream of the Redding-Anderson area, approximately 16 miles north of Red Bluff. One of the outstanding attributes of Cottonwood Creek is its status as the largest undammed tributary on the westside of the Sacramento Valley.

The creek spans a broad elevational range and functions as an important regional wildlife corridor and neotropical bird habitat. Well-developed montane, foothill, and valley riparian forests are found throughout the Cottonwood Creek Ecological Management Zone, and these forests have good connectivity with the Sacramento River Ecological Management Zone. One of the most important ecological attributes of Cottonwood Creek is its role as the primary source of coarse sediments and spawning gravel for the Sacramento River. Cottonwood Creek supplies almost 85% of the gravel introduced into the Sacramento River between Redding and Red Bluff.

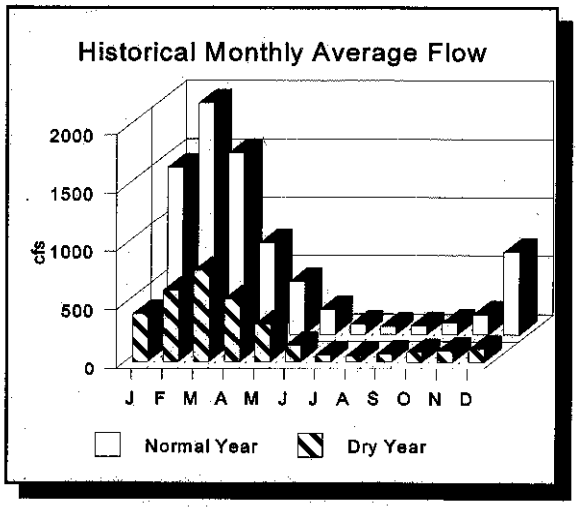
Attributes that affect the ecological health of the Cottonwood Creek Ecological Management Zone include streamflow, coarse sediment supply, gravel recruitment and transport, stream meander, and vegetation succession. Important fish and wildlife habitats include freshwater fish habitat, essential fish habitat, gravel substrate for invertebrate production and chinook salmon and steelhead spawning, riparian scrub and woodlands, and shaded riverine aquatic habitat.



Location Map of the Cottonwood Creek Ecological Management Zone and Units.

Cottonwood Creek has a natural flow pattern of high winter and low summer and fall flows, which is typical of many Sacramento Valley streams that originate in the foothills rather than at higher elevations in the Cascade or Sierra Nevada mountain ranges. In summer and fall months of low rainfall years, flows average 40 to 80 cubic feet per second [cfs]). In the wettest years, flows in winter average 5,000 to 11,000 cfs. In winter months of dry years, average monthly flows reach only 400 to 800 cfs. In the driest years, average winter monthly flows reach only 50 to 150 cfs.

In the past, streamflow in Crowley Gulch, a tributary to lower Cottonwood Creek, was intermittently augmented by the release of water from a waste gate on the Anderson-Cottonwood Irrigation District (ACID) canal. Waste gate releases during fall have attracted chinook salmon into an area where they became stranded and subsequently died without having spawned. This problem has been eliminated by operational changes by ACID personnel.



Historical Streamflow of Cottonwood Creek, 1952-1992
(Dry year is the 20th percentile year; normal year is the 50th percentile year.)

The estimated mean annual suspended sediment load transported from the Cottonwood Creek basin is second only to that of Cache Creek in the Sacramento River basin below Shasta Dam. The U.S. Army Corps of Engineers estimates that, of the total average annual gravel load transported by Cottonwood Creek, particles greater than 2.0 millimeters in diameter total approximately 19,000 tons per year. This amount is consistent with the average annual bedload of approximately 65,000 tons estimated by the U.S. Geological Survey. The California Department of Water Resources (1980) estimated that gravel mining reduced potential sand and gravel contributions to the Sacramento River by about 60%, resulting in a calculated bedload of 20,000 tons per year, with 3,000 tons of particles above one-half inch in diameter.

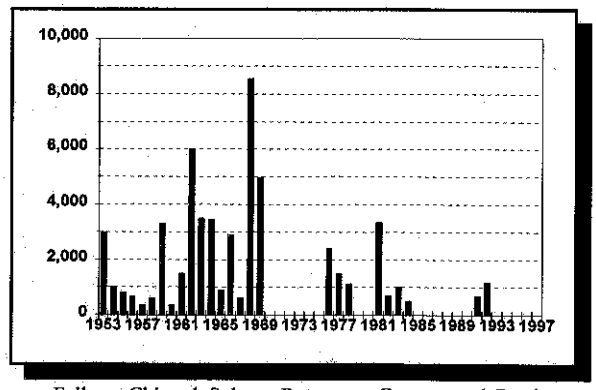
More is known about the hydrology and sediment transport process of Cottonwood Creek than about that of other streams in the northern Sacramento Valley because of studies conducted for the construction of several dams and environmental impact reports for gravel mining projects. Bankfull discharge (i.e., with the creek full to the tops of its banks) has been estimated at 20,000 cfs with a return interval of 1.8 years. The creek has a wide meander belt and a braided channel with perennial flow. The active channel width at low flow ranges from 50 to 150 feet but reaches more than 1,500 feet at bankfull discharge. The channel banks are mostly sand, gravel, and cobbles. The width of the floodplain varies, but it is generally wider and more poorly defined downstream. Sinuosity values (i.e., the ratio of creek length to the linear distance over which the creek travels) for Cottonwood Creek are low, ranging from 1.04 to 1.47. The low degree of sinuosity is attributable primarily to the high gravel and low silt and clay content of the bank material. The main channel tends to change course during large floods, resulting in a fairly wide belt of distributary channels and abandoned stream courses.

Some of the fish, wildlife, and plant resources dependent on the ecological health of Cottonwood Creek are fall-run, late-fall-run, and spring-run chinook salmon and steelhead trout. Although northern spotted owls, northwestern pond turtles, and foothill yellow-legged frogs in the South Fork will benefit from proposed restoration actions,

these species are not a direct focus of actions in the Cottonwood Creek Ecological Management Zone.

The use of Cottonwood Creek by chinook salmon and steelhead trout is determined by the timing of rainfall. In years when storms arrive late in the season, the migration of salmon and steelhead is delayed. In some years, early rainfall allows salmon to enter the creek and spawn, but subsequent low winter and spring flows limit the production of young salmon.

The average annual return of fall-run salmon is approximately 1,000 to 1,500 adults but has ranged from a few hundred to more than 8,000 fish. The return of late-fall-run salmon is much smaller, consisting of fewer than 500 fish each year. The late-fall-run salmon enter Cottonwood Creek and spawn in the main stem and lower reaches of the North, Middle, and South Forks of the creek.



Fall-run Chinook Salmon Returns to Cottonwood Creek, 1953-1997.

Salmon spawning gravel habitat in the lower reaches of Cottonwood Creek has been degraded. Some areas are covered entirely with sand and silt, and others are compacted with sediments or have become armored. Silt in Cottonwood Creek is derived from many sources; some of these sources are natural, but most are a result of undesirable land use practices, including timber harvesting and road-building activities on private and public land in the upper watershed. Overgrazing, wildfires, extensive land clearing in the foothill and valley areas, and discharges of decomposed granite from Rainbow Dam are also sources of sediment.

Streamflow, coarse sediment supply, and stream meander are closely linked. Together, these processes support and promote the regeneration of healthy riparian and riverine plant communities. Important restoration components include protecting the floodplain and existing stream meander characteristics of Cottonwood Creek.

Important functions of the upper watershed of Cottonwood Creek are to moderate streamflows resulting from storm events and to provide high quality water to the Sacramento River and Delta. Erosion from timber harvest, road building, and the adverse affects of grazing practices diminish the watershed's ability to moderate flows and provide high quality water. The potential for catastrophic wildfire can be reduced by fuel management programs.

Cottonwood Creek has an extensive riparian and riverine aquatic plant community that can be enhanced by improved land management and maintenance of natural sediment supply. Denuded areas need an opportunity to regenerate, and existing riparian forest needs protection.

Water conveyance structures in the lower sections of Cottonwood Creek impair the upstream passage of adult chinook salmon and steelhead. Restoring natural sediment supply can alleviate these problems over time and permit unobstructed access to important aquatic habitats.

Extensive gravel mining in Cottonwood Creek has damaged spawning habitat and significantly reduced gravel recruitment to the Sacramento River. In addition, gravel mining creates passage and stranding problems for fish by allowing the creek to spread over the large extraction area.

During spring, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run chinook salmon to summer holding areas.

The Cottonwood Creek Ecological Management Zone includes two ecological management units: the Upper Cottonwood Creek Ecological Management Unit and the Lower Cottonwood Creek Fan Ecological Management Unit.

List of Species to Benefit from Restoration Actions in the Cottonwood Creek Ecological Management Zone

- chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- plants and plant communities.

Descriptions of Ecological Management Units

Upper Cottonwood Creek

The Upper Cottonwood Creek Ecological Management Unit provides the streamflow and coarse sediments needed to maintain the overall ecological health of lower Cottonwood Creek and the Sacramento River. Important stream reaches in the Upper Cottonwood Creek Ecological Management Unit include the South and North Forks of Cottonwood Creek, Beegum Creek, and the mainstem reach of Cottonwood Creek above the confluence with the South Fork. The Upper Cottonwood Creek Ecological Management Unit can sustain important migration, holding, spawning, rearing, and emigration habitats for fish and wildlife species if streamflows are maintained and watersheds are rehabilitated.

The South Fork of Cottonwood Creek contains good to outstanding riparian vegetation in the foothills and lower stretches. Spring-run chinook salmon and steelhead trout can migrate to the headwaters of the South Fork, using Maple Gulch as their principal holding area. The length of the stream system below natural fish barriers is 130 linear miles, which includes the three main forks of the creek and Beegum Creek.

Spring-run chinook salmon enter Cottonwood Creek and migrate to the headwaters of the South and Middle Forks during April, May, and June. The two principal holding areas are the South Fork above Maple Gulch and Beegum Creek, a tributary to the Middle Fork. During spring of drier years, low flows and high water temperatures may impede or prevent the upstream migration of adult spring-run salmon to summer holding areas. There are no recent estimates of spring-run chinook populations; however, historic runs averaged approximately 500 salmon.

Steelhead trout enter Cottonwood Creek during late fall and early winter and spawn during winter and spring. The upper reaches of the Middle Fork, Beegum Creek, and the South Fork provide spawning and nursery areas. There are no recent estimates of steelhead populations for Cottonwood Creek. The creek also supports resident rainbow trout and brown trout in the upper tributaries.

Lower Cottonwood Creek

The Lower Cottonwood Creek Ecological Management Zone can provide important spawning areas for fall- and late-fall-run chinook salmon. Gravel transport through lower Cottonwood Creek is a significant ecological function and sufficient streamflows are needed to provide sediment transport and gravel cleansing. A long-term effort will be implemented to restore and maintain plant communities along the creek.

Salmon spawning areas in the lower reaches of Cottonwood Creek have been degraded. Some areas are entirely covered with sand and silt, and others are compacted with sediments or have become armored during floodflows. Sedimentation binds the gravel together, which prevents salmon from creating redds (salmon spawning nests); it also reduces intergravel oxygen transport, so eggs

deposited in the gravel do not survive. Armoring results when gravel is washed away during floods, leaving rocks and boulders too large for salmon to move during spawning.

Gravel has been mined in the lower Cottonwood Creek fan for many years. Gravel extraction damages spawning areas in the creek and reduces the recruitment of spawning gravel to the Sacramento River. Two major instream gravel extraction projects operate in Cottonwood Creek below the Interstate 5 bridge.

VISIONS FOR THE ECOLOGICAL MANAGEMENT ZONE AND UNITS

The vision for the Cottonwood Creek Ecological Management Zone is to restore natural streamflow patterns, coarse sediment supply, natural floodplain and flood processes, and riparian forest and riverine aquatic habitats. In addition, the proposed restoration actions are designed to reduce or eliminate to the extent necessary stressors that impair ecological processes, including gravel mining operations, structures that inhibit chinook salmon and steelhead trout migrations, and land use activities (e.g., water diversions, logging, and grazing).

A restored Cottonwood Creek will provide incremental benefits to the overall objective of restoring and maintaining important aquatic species, such as chinook salmon and steelhead trout, in Cottonwood Creek and in the Sacramento River. With restoration, Cottonwood Creek Ecological Management Zone will support sustainable populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout after natural sediment supply and gravel recruitment, cleansing, and transport processes are reactivated; gravel spawning and riparian habitats are restored; and the adverse effects of upper watershed diversions, logging, and grazing are reduced.

VISION FOR UPPER COTTONWOOD CREEK

The vision for the Upper Cottonwood Creek Ecological Management Zone is to maintain coarse sediment recruitment, cleansing, and transport; improve habitat for chinook salmon, steelhead trout, and other native fishes; improve habitat corridors for wildlife populations; and restore riparian and riverine plant communities through improved land use and forest management practices.

The Cottonwood Creek watershed is a high-value area, both because it is a distinct Ecological Management Zone and because of its linkage with the Sacramento River Ecological Management Zone. Restoring and maintaining ecological processes and functions related to streamflow, sediment supply, gravel recruitment, cleansing, and transport, and the creation and maintenance of habitats can best be achieved by developing and implementing a local watershed management plan. The creation of a watershed management plan by a local watershed conservancy or planning agency is necessary. This planning effort would evaluate and develop recommendations for timber harvesting, land use, fire and fire suppression, and the management of oak woodland habitats to reduce erosion, maintain riparian zones, and provide for more sustained runoff patterns.

VISION FOR LOWER COTTONWOOD CREEK

The vision for the Lower Cottonwood Creek Ecological Management Zone is to restore, reactivate, and maintain coarse sediment supply, floodplain and flood processes, gravel recruitment, and stream meander. The vision also includes reducing stressors on these processes, including gravel mining activities in the Cottonwood Creek stream corridor.

Instream gravel extraction should be managed to protect salmon spawning and rearing habitat within Cottonwood Creek and to maintain and enhance sediment supply to the Sacramento River. Implementing such management would result in immediate benefits to salmon in Cottonwood Creek and the Sacramento River. Spawning gravel is a finite resource in the Sacramento River system, and Cottonwood Creek contains one of the most important reserves.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS: Streamflows shape the stream channels, support riparian vegetation, and transport nutrients and sediments. The vision for streamflows in Cottonwood Creek is to emulate the natural runoff pattern with a late-summer or early fall flow event.

COARSE SEDIMENT SUPPLY: Coarse sediments are abundant in Cottonwood Creek; however, gravel recruitment has diminished because of extensive mining activities. The vision is that restoring natural gravel recruitment and sediment transport processes will contribute to maintaining important habitat substrates and ecological processes in Cottonwood Creek and the Sacramento River.

STREAM MEANDER: In unimpaired systems, streams meander within their historic floodplains. This meander contributes sediments for transport and deposition, rejuvenates riparian succession, and creates new habitats for fish and other aquatic species. The vision is that a natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: Coarse sediment supply, stream meander, and floodplain and flood processes are closely interrelated. The vision is that all three of these processes will moderate channel incision and scour by providing areas for bank overflow, contribute to species diversity by creating landforms that support different community structure, provide low-velocity refuge for fish and other aquatic organisms during floods.

VISIONS FOR HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS: Health riparian habitat provides a migratory corridor for terrestrial species that connects low and higher elevation habitats. Shaded riverine aquatic habitat provides shade, contributes to moderating stream temperatures, and provides woody debris, which juvenile fish use as escape and resting cover. The vision is that Cottonwood Creek will support healthy riparian, shaded riverine aquatic and woody debris habitats, which in turn will support improved survival of aquatic and terrestrial species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. Upper Cottonwood Creek is typical of a salmon-steelhead stream and lower Cottonwood Creek is typical of a fall chinook salmon spawning stream (Moyle and Ellison 1991). The vision is to maintain the quality of freshwater fish habitat in Cottonwood Creek through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: Cottonwood Creek has been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). The vision is to maintain or restore EFH in Cottonwood Creek including substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space;

access and passage; and flood plain and habitat connectivity.

VISION FOR REDUCING OR ELIMINATING STRESSORS

GRAVEL MINING: Coarse sediment supply in Cottonwood Creek is adversely affected by gravel mining. This lack of instream sediments affects stream channel morphology, stream meander, and riparian systems. The vision for Cottonwood Creek is that gravel mining activities will be relocated to areas outside the active stream channel.

VISIONS FOR SPECIES

CHINOOK SALMON: The vision for Central Valley chinook salmon is to recover all stocks presently listed or proposed for listing under ESA and CESA, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that use fully existing and restored habitats. The fall-, spring-, and late-fall-runs of chinook salmon depend on Cottonwood Creek's streamflow, natural sediment supply, and riverine aquatic habitats. The vision is that Cottonwood Creek will provide for sustainable chinook salmon populations.

STEELHEAD: The visions of steelhead is to recover this species listed as threatened under ESA. Steelhead use Cottonwood Creek and will benefit from many of the actions that will improve conditions for chinook salmon. The vision is that Cottonwood Creek will support a sustainable steelhead population.

LAMPREY: The vision for lamprey is to maintain and restore population distribution and abundance to higher levels that at present. The vision is also to better understand life history and factors in Cottonwood Creek which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

Maintaining and restoring the ecological health of the Cottonwood Creek Ecological Management Zone and its respective Ecological Management Zones will depend primarily on cooperative endeavors to locate alternative sources of water in the upper watershed and to eliminate gravel extraction operations in the lower creek.

WATERSHED MANAGEMENT PLANNING

Restoration of this Ecological Management Zone requires developing and implementing a comprehensive watershed management program for the upper and lower areas. Eliminating gravel extraction operations will increase the delivery of sediments to the Sacramento River, improve upstream fish passage, improve spawning habitat for chinook salmon using the lower reach, and allow for restoring a riparian corridor and a clearly defined stream channel. Improved watershed management in the upper watershed will protect streamflow, gravel sources, spawning and rearing habitat of salmon and steelhead, and wildlife habitats.

AGGREGATE RESOURCE MANAGEMENT PLAN

In attaining the vision for the Cottonwood Creek Ecological Management Zone, ERPP encourages gravel operators and the local counties to cooperatively develop and implement an aggregate resource management plan (ARMP). Potential measures in a county wide ARMP would include recommendations or requirements for:

- limiting instream extraction to less than the sustained yield of the system while providing sediment input to the Sacramento River,
- implementing measures to prevent channel incision, such as installing stream grade control structures, and
- revegetating all permanently exposed land that has been denuded by mining operations.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

The Central Valley Project Improvement Act (CVPIA) added "mitigation, protection and restoration of fish and wildlife" as a purpose of the Central Valley Project. It required the implementation of a program that makes all reasonable efforts to increase the natural production of anadromous fish in Central Valley rivers and streams to not less that twice the average levels present from 1967 to 1991.

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the CVPIA, which provides for restoring habitats and species and eliminating many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1995) and the Anadromous Fish Screening Program. Other elements are directed at spawning gravel replenishment on the Sacramento River below Keswick Dam, water acquisition, and other measures that will contribute to health of the Cottonwood Creek, Sacramento River and Sacramento-San Joaquin Delta Ecological Management Zones.

SALMON, STEELHEAD TROUT AND ANADROMOUS FISHERIES PROGRAM ACT

Established in 1988 by Senate Bill 2261, this Act directs the California Department of Fish and Game (DFG) to implement measures to double the numbers of salmon and steelhead present in the Central Valley (DFG 1993, 1996). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and to assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

CALFED BAY-DELTA PROGRAM

CALFED has funded two ecosystem restoration projects in Cottonwood Creek. One project funded the formation of a watershed group and another funded restoration of the creek channel.

Linkage to Other Ecological Management Zones

Cottonwood Creek can support larger populations of fall-, late-fall-, and spring-run chinook salmon and steelhead trout, but there are many stressors outside the Cottonwood Creek Ecological Management Zone that impair or reduce the survival of adult and juvenile chinook and steelhead. Restoration efforts in the Sacramento River, Sacramento-San Joaquin Delta, and Suisun Marsh/San Francisco Bay Ecological Management Zones will all contribute to improved returns of adult fish.

In addition, the gravel recruitment, cleansing, and transport functions of Cottonwood Creek are critical to maintaining the long-term ecological health of the Sacramento River Ecological Management Zone and the fish, wildlife, and plant resources that it supports.

Restoration Targets and Programmatic Actions

Ecological Processes

Central Valley Streamflows

Target 1: During summer and fall, more closely emulate the seasonal streamflow pattern, so that flows are sufficient for chinook salmon holding and spawning in most year types by providing up to 20 to 50 cfs. These flows can mobilize and transport sediments, allow upstream and downstream fish passage, create point bars, and contribute to stream channel meander and riparian vegetation succession (◆).

Programmatic Action 1a: Augment summer and fall flow in Cottonwood Creek by purchasing water from willing sellers and developing alternative supplies.

Rationale: *The streams in the Cottonwood Creek Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout and for fall-run chinook salmon in some years. One of the key attributes of streamflow in this Ecological Management Zone is to provide for successful upstream passage of adult fish and fish spawning. In some years, flows are insufficient to provide fish passage or recede too quickly after fish spawn and expose or dewater redds containing incubating eggs or sac fry. In addition, flow in Cottonwood Creek is the power that drives many ecological functions and processes linked to stream channel morphology, sediment transport and gravel recruitment, riparian communities, and fish habitat.*

Instream flow needs on Cottonwood Creek should be subject to focused research to determine if the proposed flow increase of 20 to 50 cfs is appropriate.

Coarse Sediment Supply

Target 1: Maintain existing levels of erosion and gravel recruitment in streams in the Cottonwood Creek Ecological Management Zone, and provide for increasing the transport of these sediments to the Sacramento River by an average of 30,000 to 40,000 tons per year (◆◆◆).

Programmatic Action 1a: Cooperatively develop and implement a gravel management program for Cottonwood Creek. The program would protect and maintain important ecological processes and functions related to sediment supply, gravel recruitment, and gravel cleansing and transport. This would involve working with state and local agencies and gravel operators to protect spawning gravel and enhance recruitment of spawning gravel to the Sacramento River in the valley sections of Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Cooperate with the aggregate resource industry to relocate existing gravel operations on Cottonwood Creek to areas outside of the active stream channel.

TARGET 2: Repair and rehabilitate spawning gravels in 10 to 20 miles of the lower South Fork and mainstem of Cottonwood Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: In the short term, develop a cooperative program to rip and clean or reconstruct important salmon spawning riffles on the South Fork Cottonwood Creek and on lower Cottonwood Creek below the South Fork.

RATIONALE: *Gravel deposits in the lower South Fork and in the mainstem below the South Fork are essential to maintaining spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Historically, Cottonwood Creek was one of the most important sources of gravel to the Sacramento River. Since Shasta Dam was completed in the 1940s, Cottonwood Creek has become the single largest contributor of coarse sediments. Improving and maintaining sediment sources and transport capabilities of this stream are essential components necessary to restore and maintain the ecological health of the Sacramento River.*

Gravel transport is the process whereby flows carry away finer sediments that fill gravel interstices (i.e., spaces between cobbles). Gravel cleansing is the process whereby flows transport, grade, and scour gravel. Gravel transport and cleansing by flushing most of the fines and the movement of bedload (the load of material carried downstream in the streambed by flow) are important to maintaining the amount and distribution of spawning habitat in the Cottonwood Creek basin. Although these processes have been greatly reduced or altered as a result of human activities, they can be restored and maintained by changing water flow and sediment supplies, removing stressors, or directly manipulating channel features and stream vegetation. Gravel deposits in the lower South Fork and in the mainstem below the South Fork have been adversely affected by sedimentation from upstream sources in the watershed. Mechanical means will be used infrequently to free excessive quantities of fine sediments from the gravel substrates until upstream sources of sediment have been reduced or eliminated through watershed management and restoration.

STREAM MEANDER

TARGET 1: Preserve or restore the 50- to 100-year floodplain and existing channel meander characteristics of streams in the Cottonwood Creek Ecological Management Zone, particularly in low-gradient areas throughout the lower 20 miles where most deposition occurs and where stream channel meander is most pronounced (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate reestablishing the floodplain along the lower reach of Cottonwood Creek, and evaluate constructing setback levees to reactivate channel meander in areas presently confined by levees.

PROGRAMMATIC ACTION 1B: In the short term, develop a cooperative program to mechanically create a more defined stream channel in lower Cottonwood Creek. This would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connectivity with the Sacramento River until natural meander returns.

RATIONALE: *Stream meander belts are the area in which natural bank erosion and floodplain and sediment bar accretions occur along stream courses. Natural stream meander in Cottonwood Creek functions dynamically to transport and deposit sediments and provide transient habitats important to algae, aquatic invertebrates, and fish. Meander also creates surfaces that are colonized by natural vegetation that support wildlife. Cottonwood Creek is a nondammed tributary and*

a significant source of sediment to the Sacramento River. To maintain the creek's natural stream channel and fluvial dynamic processes and to provide long-term resilience for its watershed and stream channel processes in the Sacramento River, Cottonwood Creek should be fully restored and protected.

NATURAL FLOODPLAINS AND FLOOD PROCESSES

TARGET 1: Develop a cooperative program to identify opportunities to allow Cottonwood Creek to seasonally inundate its floodplain.

PROGRAMMATIC ACTION 1A: Conduct a feasibility study to determine means by which to increase floodplain interactions on lower Cottonwood Creek.

PROGRAMMATIC ACTION 1B: Minimize adverse effects of permanent structures such as bridges on floodplain processes.

RATIONALE: *Natural functioning floodplain processes on Cottonwood Creek are equally important with stream meander and natural sediment supply. A conceptual model of these interactions needs to be developed to further understand the dynamic structure of Cottonwood Creek and to allow the design and implementation of future actions to protect and restore these important ecological functions.*

TARGET 1: Restore upper watershed health (◆◆◆).

PROGRAMMATIC ACTION 1A: Reduce excessive fire fuel loads in upper watersheds.

PROGRAMMATIC ACTION 1B: Improve forestry management practices, including timber harvest, road building and maintenance, and livestock grazing practices.

PROGRAMMATIC ACTION 1C: Cooperatively evaluate the development of a watershed management program that could contribute to improved runoff patterns in the Upper Cottonwood Creek Ecological Management Unit.

TARGET 2: Protect, restore, and maintain the Cottonwood Creek watershed by eliminating conflict between land use practices and watershed health (◆◆◆).

PROGRAMMATIC ACTION 2A: Cooperatively work with landowners and federal land management agencies to facilitate watershed protection and restoration and reduce siltation to improve holding, spawning, and rearing habitats for salmonids.

PROGRAMMATIC ACTION 2B: Develop a cooperative program to implement improved fencing, grazing, and other land management practices on private and national forest lands, and encourage local counties to adopt stronger grading and road building ordinances to control erosion.

RATIONALE: *Resolving conflicts regarding land use in the Cottonwood Creek Ecological Management Zone must stress ecosystem processes and functions, habitats, and aquatic and terrestrial organisms. Land use activities that may be harmful include urban and industrial development, land reclamation, water conveyance facilities, livestock grazing, and agricultural practices.*

Improved watershed processes will maintain and restore seasonal water runoff patterns, water yield, and water quality and reduce sediment load to downstream storage reservoirs (reducing storage capacity and improving water quality). Healthier watersheds will also provide ancillary benefits to upper watershed habitats and species.

HABITATS

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to establish a continuous 130-mile riparian habitat zone along upper and lower Cottonwood Creek and its tributaries through conservation easements, fee acquisition, or voluntary landowner measures (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to establish, restore, and maintain riparian habitat on Cottonwood Creek through conservation easements, fee acquisition, or voluntary landowner cooperation.

PROGRAMMATIC ACTION 1B: Encourage the development of long-term measures in the comprehensive watershed management plan to further improve water temperatures. Develop a cooperative approach with counties and local agencies to implement land use management to protect riparian vegetation along the streams. Develop programs to restore lost riparian vegetation.

PROGRAMMATIC ACTION 1C: Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along the lower reaches of Cottonwood Creek.

RATIONALE: *Many species of wildlife in the Cottonwood Creek watershed depend on or are closely associated with riparian habitats. Of all the habitat types in California, riparian habitats support the greatest diversity of wildlife species. Degradation and loss of riparian habitat have substantially reduced the habitat area available for associated wildlife species. Loss of this habitat has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for Cottonwood Creek ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitats. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Cottonwood Creek and its floodplain, and in maintaining and restoring riparian and riverine aquatic habitats.*

REDUCING OR ELIMINATING STRESSORS

DAMS AND OTHER STRUCTURES

TARGET 1: Facilitate passage of steelhead and spring-run chinook salmon to the holding, spawning, and rearing habitat in the higher elevation reaches and tributaries.

PROGRAMMATIC ACTION 1A: Begin an evaluation of structures (such as culverts, bridge abutments, grade control structures, etc.) that may be impeding or hindering migration to the high quality upstream habitat and implement measures to facilitate upstream passage.

RATIONALE: *Because Cottonwood Creek and its tributaries have no major dams, this system represents one of the best opportunities to restore*

steelhead and spring-run chinook salmon to the mid- to high-elevation habitats on which they depend. However, even in the absence of large impassable dams, migration of adults can be impaired by smaller structures, such as culverts and road grade control structures, that may not be complete barriers to migration but can hinder migration at low flows. Also, the cumulative effect of numerous structures can cause significant delays in migration, which can reduce survival. Restoring viable populations of steelhead and spring-run chinook to this system would contribute significantly to the over-all recovery of these fish in the Central Valley.

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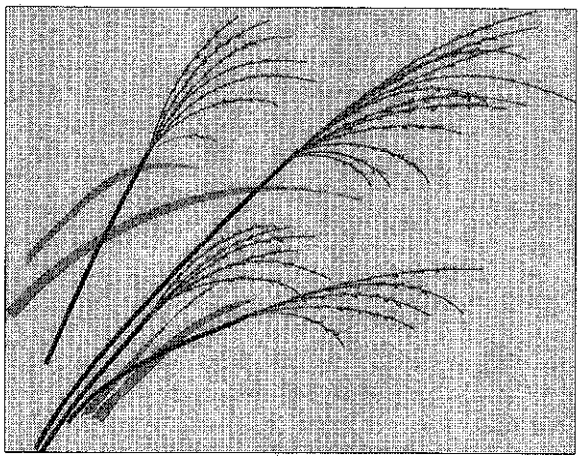
◆ COLUSA BASIN ECOLOGICAL MANAGEMENT ZONE



INTRODUCTION

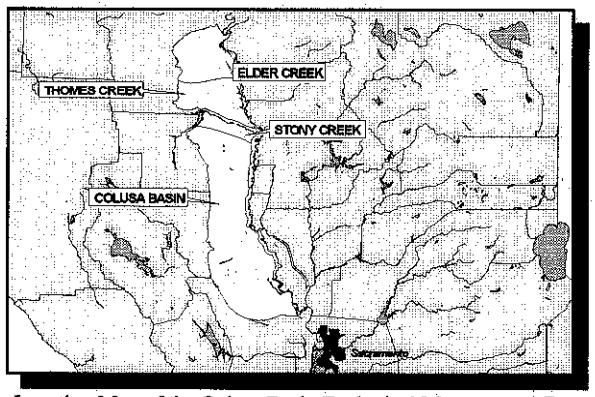
The long-term ecological health of the Delta depends on the health of its component parts. The Colusa Basin Ecological Management Zone contribution to the health of the Sacramento-San Joaquin Delta and Sacramento River Ecological Management Zones will increase after its ecological processes, habitats, and ability to support sustainable fish, wildlife, and plant communities are improved. The Colusa Basin Ecological Management Zone supports the Bay-Delta by contributing flow and sediment, and by providing riparian and riverine aquatic and wetland habitat that supports a wide variety of wildlife.

The streams in this Ecological Management Zone provide seasonally important rearing habitat for many fish species found in the Sacramento River.

The Colusa Basin Ecological Management Zone is one of the primary waterfowl and wetland migratory birds migration and wintering areas of the Pacific Flyway. The Zone contains three National Wildlife Refuges and some critical privately owned wetlands in the Sacramento Valley. The Colusa Basin Drainage area contains vital waterfowl and wetland habitats, contributes to the filtering of agricultural return flow, and has potential for riparian restoration. The wetlands along the drain provide important habitat for endangered and threatened species. The Colusa National Wildlife Refuge has some of the highest concentrations of giant garter snake in the Central Valley.

DESCRIPTION OF THE MANAGEMENT ZONE

The Colusa Basin Ecological Management Zone is an extensive hydrologic and geographic area west of the Sacramento River between Cottonwood Creek to the north and Cache Creek to the south. This zone is divided into the Stony Creek, Elder Creek, Thomes Creek, and Colusa Basin Ecological Management Units.



Location Map of the Colusa Basin Ecological Management Zone and Units.

Protecting and improving important ecological processes and functions will help to maintain important attributes of the Colusa Basin Ecological Management Zone, and preserve its ability to serve as a source of sediment and

nutrients to the Sacramento River Ecological Management Zone.

Important ecological processes needed to provide a healthy ecosystem in the Colusa Basin Ecological Management Zone and contribute to the health of the Sacramento River are the streamflow patterns of the basin and natural sediment supply.

The three largest tributary streams in this zone (Stony, Elder, and Thomes creeks) all discharge into the Sacramento River. The Colusa Basin maintains some of its historic capacity to retain and detain floodwater. It captures the seasonal inflow from small westside tributaries that flow into it.

The soils underlying the Stony, Elder, and Thomes Creek watershed are important sediment sources to the Sacramento River.

The Colusa Basin is a particularly important area for waterfowl and shorebirds and can provide a substantial amount of seasonally flooded wintering habitat.

List of Species to Benefit from Restoration Actions in the Colusa Basin Ecological Management Zone

- lamprey
- giant garter snake
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- waterfowl
- plants and plant communities.

Descriptions of Ecological Management Units

Stony Creek Ecological Management Unit

Stony Creek is a westside stream originating in the Coast Ranges and draining into the Sacramento River south of Hamilton City. Three storage reservoirs are located in the watershed. The primary focus area on Stony Creek is the stream reach below Black Butte Dam. This includes Stony Creek from Black Butte Dam to Interstate Highway 5 (I-5), I-5 to Highway 45, and Highway 45 to the confluence with the Sacramento River.

Stony Creek has a seasonal run off pattern of high winter and very low summer and fall flows, typical of western Sacramento Valley foothill streams. Unimpaired summer and early fall flows are 0 cubic feet per second (cfs) for 8-9 months, except in high rainfall years.

Summer and fall flows are higher than unimpaired flows as water is delivered below Black Butte Dam for agricultural use. These flows generally exceed 100 cfs in summer except in the driest years, when flows of only 10 to 30 cfs are released. Fall flows are generally less than 100 cfs except in the wettest years. Essentially no surface flows reach the Sacramento River during the summer and fall.

Water is diverted from several locations along the Stony Creek system below Black Butte Dam. About 150 cfs is diverted for irrigation from Black Butte Reservoir into the North Diversion Canal. Additional water is diverted at the South Diversion Canal, into the Tehama-Colusa Canal (TCC) east of Orland, and into the Glenn-Colusa Canal before the creek enters the Sacramento River.

Historically, riparian vegetation along Stony Creek below the site of Black Butte Dam was virtually non-existent.

A recent soil and mineral classification study by Glenn County indicates that Black Butte Reservoir has captured about 41 million cubic yards of sediment (Glenn County 1996).

ELDER CREEK ECOLOGICAL MANAGEMENT UNIT

Elder Creek is a westside tributary that enters the Sacramento River 12 miles south of Red Bluff. It flows into the Sacramento Valley from the west, draining a watershed of approximately 142 square miles. The watershed contains mostly shale, mudstone, and fine sedimentary deposits that produce minimal amounts of gravel, most of which is deposited where the stream enters the valley. No large gravel deposits are present in the lower stream reaches. An flood-control levee system in the lower section has directed and concentrated flows, increasing sediment transport and degradation throughout the reach.

Several small water diversions, but no large dams, have been constructed on Elder Creek. The flow is generally intermittent, with a widely fluctuating flow regime. Flow records indicate peak flows of more than 11,000 cfs, but the stream is normally dry from July to November.

Elder Creek has a natural flow pattern of moderate winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. Summer and early fall flows are near 0 cfs, except in the highest rainfall years. In the wettest years, winter flows average 600 to 1,600 cfs. In the driest years, average monthly winter flows are only 5 to 20 cfs.

The stream reach from Rancho Tehama to the mouth is a low-gradient, braided channel. Approximately 20 miles upstream of the valley floor, the stream gradient increases rapidly in a rugged canyon area that supports resident fish, but probably has limited value for steelhead.

THOMES CREEK ECOLOGICAL MANAGEMENT UNIT

Thomes Creek is the largest gravel source in Tehama County. The stream has a watershed area of about 300 square miles. Thomes Creek enters the Sacramento River 4 miles north of Corning. No large dams have been constructed on the stream. The stream is usually dry or flowing intermittently below the U.S. Geological Survey (USGS) stream gage near Paskenta until the first heavy fall rains.

Thomes Creek has an unimpaired natural pattern of flashy winter and spring flows and very low summer and fall flows, typical of streams in the western Sacramento Valley foothills. The short-duration, high volume flows may impair riparian revegetation. Summer and early fall flows are near 0 cfs, except in the wettest years. Precipitation is seasonal, with more than 80 percent in December, January, and February. Precipitation in the drainage varies with elevation. The average annual rainfall is 15 to 45 inches

The lower reach of Thomes Creek has been significantly altered by the construction of flood-control levees and bank protection projects.

The lower Thomes Creek reaches contain large amounts of sediment and gravel. Thomes Creek has at least three year-round gravel mining operations and several seasonal ones. These gravel mining operations are conducted in compliance with the county gravel resource plan and permitted under terms of the Department of Fish and Game.

Thomes Creek is one of the most intact tributaries on the west side of the Sacramento Valley. Thomes Creek provides important spawning habitat for native Central Valley fish, such as Sacramento sucker, and Sacramento pikeminnow (squawfish). These native species may be a reason why the area is used by wintering bald eagles.

Some experts believe that Thomes Creek ranks second in importance, behind Cottonwood Creek, in terms of conservation priorities on the west side of the valley. Thomes Creek is in remarkably good condition in the upper watershed and has a well-developed riparian forest along much of its upper reach.

COLUSA BASIN ECOLOGICAL MANAGEMENT UNIT

The Colusa Basin drainage area extends from the Coast Ranges on the west to the Sacramento River on the east. It received flow and sediment from small streams located between Stony Creek on the north and Cache Creek on the south. The drainage encompasses approximately 1,500 square miles in Glenn, Colusa, and Yolo counties; 570 square miles of this area consists of the respective watersheds of the westside tributaries, with the rest located in the relatively flat valley bottom. Numerous small streams, including forks and branches, constitute the watershed, about 11 of which flow directly into the Colusa Basin Drain. Access to the upper portions of most smaller westside tributary streams is blocked where the GCID canal intersects the streams.

The main conveyance system in the Colusa Basin is known as the Colusa Trough, the Reclamation District 2047 Drain, the Colusa Basin Drainage Canal, or, more commonly, the Colusa Basin Drain. Flows in the basin generally discharge into the Sacramento River heading southeast through various sloughs. Reclamation efforts that began in the 1850s have converted wetlands and sloughs into agricultural areas.

Agricultural drainwater from the basin also enters the Sacramento River near Knights Landing through the Knights Landing Ridge Cut. In past years, this return water contributed to elevated water temperatures in the lower Sacramento River below the town. Water temperatures during May and June often exceeded 70°F, which is detrimental to juvenile chinook salmon. Recent improvements in agricultural and water management practices, reduced flow volume and reduced temperature and chemical loading, have diminished the problems formerly related to drainwater.

The Colusa Basin Ecological Management Unit provides important seasonal and permanent habitats for many species of migratory waterfowl and shorebirds, and the federally listed giant garter snake.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Colusa Basin Ecological Management Zone is to maintain or rehabilitate important fishery, wildlife, and plant communities and ecological processes and functions that contribute to the health of the Delta. Attaining this vision will involve restoring or reactivating important ecological processes and functions that create and maintain habitats for fish, wildlife, and plant communities throughout the Ecological Management Zone and its component Ecological Management Units.

This vision focuses on restoring ecological processes and functions related to sediment transport and restoring seasonally flooded aquatic habitats that provide important wintering areas for waterfowl and shorebird guilds, and in providing wetland habitats that will contribute to the recovery of the giant garter snake. The vision also included a large cooperative program with landowners to improve the wildlife benefits related to agricultural practices in the area. In addition, it emphasizes maintenance or improvements to the ecological processes and improvements to fish habitats. Visions for these ecosystem elements follow.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

STONY CREEK ECOLOGICAL MANAGEMENT UNIT

Many native fish species use the lowermost reach of Stony Creek, below Highway 45, at its confluence with the Sacramento River for rearing from fall through early summer when water is suitably cool. The vision is to maintain and improve valuable aquatic and terrestrial habitat types by restoring upstream areas to improve system integrity and increase habitat complexity at the confluence.

ELDER CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Elder Creek Ecological Management Unit is to restore degraded habitat, the sediment balance (to reduce the quantity of fine sediments in the gravel substrate),and a more natural stream channel and riparian habitat in the lower section.

Because of levees and other structures, Elder Creek transports sediment through the lower sections instead of allowing deposition.

Elder Creek's lower reach and its confluence with the Sacramento River may occasionally provide an important seasonal, and sometimes extended, rearing habitat for juvenile anadromous and resident fish. Maintaining and improving the ecological processes related to streamflow; sediment supply; a and transport will also provide a clearly defined stream channel and riparian zone.

THOMES CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Thomes Creek Ecological Management Unit is to establish a clearly defined stream channel, consistent with flood control needs, to effectively enhance sediment transport in the lower stream reach to improve sediment delivery to the Sacramento River.

COLUSA BASIN ECOLOGICAL MANAGEMENT UNIT

The vision for the Colusa Basin Drain Ecological Management Unit is to remedy ecological problems related to the Colusa Basin Drain and the mainstem Sacramento River and to maintain and improve the area's value in providing seasonally flooded wetland habitat.

The Colusa Basin Drain is sometimes a significant source of warmwater inflow to the Sacramento River, but is probably not a significant problem during May and June. In general, rice floodup and maintenance precludes significant drainwater during this period. There may be thermal impacts resulting from rice field dewatering prior to harvest in late August and September. The drain may also draw chinook salmon from their natural migratory corridor, resulting in their loss to the spawning population.

VISIONS FOR ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOW: The vision is that streamflows would be maintained to support many ecological processes and functions essential to the health of individual streams in the Colusa Basin Ecological Management Zone and contribute to the health of the mainstem Sacramento River.

COARSE SEDIMENT SUPPLY: The vision for sediment supply in streams of the Colusa Basin Ecological Management Zone is that natural stream sediments will contribute to stream channel formation and provide for native resident fish spawning and invertebrate production.

NATURAL FLOODPLAIN AND FLOOD PROCESSES: The Colusa Basin is one of the Sacramento Valley's natural overflow basins. The vision is to maintain the system's flood capacity,

introduce nutrients to the system, and support natural regeneration and succession of riparian and riverine plant communities.

VISION FOR HABITATS

SEASONAL WETLAND HABITAT: The vision is that increased seasonal flooding of leveed lands, use of the Colusa Basin's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

RIPARIAN AND RIVERINE AQUATIC HABITAT: The vision is to maintain existing riparian and shaded riverine aquatic habitats and to restore these habitats where feasible that support terrestrial and aquatic species. Throughout much of this zone, riparian protection and restoration will be in conjunction with flood control and levee maintenance practices.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The lower sections of these creeks are typical of fall chinook salmon spawning streams (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in the Colusa Basin Ecological Management Zone has been tentatively identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Colusa Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS: Pesticides and herbicides are applied extensively in this Ecological Management Zone and may adversely affect aquatic organisms. The vision is that contaminant input levels to the system will not impair restoration or maintenance of healthy fish, wildlife, and plant communities.

VISIONS FOR SPECIES

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Colusa Basin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels

that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Colusa Basin Ecological Management Zone and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The vision for the Colusa Basin Ecological Management Zone can be achieved by primarily relying on local resource conservation districts, landowner associations, watershed associations, watershed conservancies, water districts, and local landowners. In addition, the expertise of state, federal and local agencies can be used where appropriate to improve or assist in local planning efforts. Local groups presently include the Stony Creek Business and Landowners Coalition, the Thomes Creek Watershed Association, Tehama Colusa Canal Authority, and the Orland Unit Water Users Association. Key agencies in this effort are DFG, USFWS, the U.S. Natural Resources Conservation Service (NRCS), Reclamation, and local government agencies. The Colusa Basin Drainage District will play an important part in designing restoration efforts in the Colusa Basin Ecological Management Unit. The District recently completed major elements of a Basin Integrated Resource Management Plan and Watershed Priority Ranking Assessment Study. This planning process brought together representatives from agricultural, environmental, urban, and rural groups to identify, discuss, and resolve issues in a way that benefits all parties. In addition, local landowners, stakeholders, and private organizations will be important to restoration program success.

CENTRAL VALLEY HABITAT JOINT VENTURE

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Colusa Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CENTRAL VALLEY PROJECT IMPROVEMENT ACT

In addition to many provisions for the restoration of anadromous fish in the Central Valley, the Central Valley Project Improvement Act contains provisions related to "other" programs to protect, restore, and mitigate for past fish and wildlife impacts of the Central Valley Project including threatened and endangered plants and animals.

CALFED BAY-DELTA PROGRAM

CALFED has funded one ecosystem restoration projects in Colusa Basin. This project reduces sediment inflow to Sand and Salt creeks.

LINKAGE TO OTHER ECOLOGICAL MANAGEMENT ZONES

The Colusa Basin Ecological Management Zone is closely linked to the Sacramento River Ecological Management Zone and has a high degree of connectivity through the confluences of Stony, Elder, and Thomes Creeks. The Colusa Basin is directly linked to the Sacramento River through the Colusa Basin Drain. This Ecological Management Zone provides important habitats for

a variety of migratory species including anadromous fish, waterfowl, and other species dependent on wetland and riparian habitats.

RESTORATION TARGETS AND PROGRAMMATIC ACTIONS

ECOLOGICAL PROCESSES

CENTRAL VALLEY STREAMFLOWS

TARGET 1: Maintain the existing seasonal runoff patterns that mobilize and transport sediments, allow upstream and downstream resident fish passage, and contribute to riparian vegetation succession. (◆).

PROGRAMMATIC ACTION 1A: Develop locally initiated programs to restore upper watershed health and functions.

PROGRAMMATIC ACTION 1B: Reduce excessive fire fuel loads in the upper watersheds.

PROGRAMMATIC ACTION 1C: Improve forestry management practices related to timber harvesting, road building and maintenance, and livestock grazing.

PROGRAMMATIC ACTION 1D: Develop a watershed management plan for Thomes Creek.

PROGRAMMATIC ACTION 1E: Develop a watershed management plan for Elder Creek.

PROGRAMMATIC ACTION 1F: Develop a watershed management plan for Stony Creek.

RATIONALE: *Colusa Basin Ecological Management Zone streams provide several features that are important within the Ecological Management Zone and for adjacent zones. Major ecological processes and functions that are driven by flow include gravel recruitment, transport, deposition, and cleansing. Stony, Thomes, and Elder creeks can provide sediment for transport to the Sacramento River and habitat in the Sacramento River for chinook salmon and other aquatic species. Maintaining and improving the ecological health of streams in the Colusa Basin Ecological Management Zone will require maintaining existing runoff patterns and eliminating other stressors such as invasive exotic plants (Arundo and tamarisk) that constrain ecological processes. In addition, improvements in watershed health will contribute to maintaining seasonal runoff patterns, water yield, and water quality and reduce sediment loading to downstream storage reservoirs.*

COARSE SEDIMENT SUPPLY

TARGET 1: Maintain the sediment available for transport during storms and seasonal flow events in Thomes Creek (◆◆).

PROGRAMMATIC ACTION 1A: Maintain sediment transport in Thomes Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River.

TARGET 2: Maintain the quantity of sediment transported from Elder Creek to the Sacramento River (◆◆).

PROGRAMMATIC ACTION 2A: Maintain sediment transport in Elder Creek by continuing to monitor aggregate extraction activities to ensure sediment is available for delivery to the Sacramento River

RATIONALE: *Sand and gravel extraction activities on the streams in the Colusa Basin Ecological Management Zone are conducted in compliance with local and state regulations. The tributaries are important sediment sources for the Sacramento River. Sediments contribute to several important ecological functions and are required for specific habitats, particularly chinook salmon and steelhead habitats. Black Butte Dam on Stony Creek has eliminated natural gravel recruitment*

to the lower stream reach. The feasibility of protecting Stony Creek, its stream and riparian corridor, and its contribution of sediment to the Sacramento River should be evaluated.

NATURAL FLOODPLAIN AND FLOOD PROCESSES

TARGET 1: Establish a desirable sediment deposition level in the Colusa Basin (◆).

PROGRAMMATIC ACTION 1A: Improve the Colusa Basin sediment deposition capacity by working with local landowners to develop an integrated plan consistent with flood-control requirements.

RATIONALE: *Floodplain processes include the natural floodwater and sediment detention and retention process whereby flows and sediment are retained within the floodplains. Retaining and detaining water and sediment in basin floodplains are controlled primarily by flow patterns and channel geomorphology, and secondarily by soils and plant communities.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Protect and manage 2,000 acres of existing seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 2,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,435 acres of existing public and private seasonal wetland habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Colusa Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Colusa Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND SHADED RIVERINE AQUATIC HABITATS

TARGET 1: Protect and maintain riparian vegetation along Stony Creek, Elder Creek, Thomes Creek, and the Colusa Basin Ecological Management Unit channels and sloughs where possible. This will provide cover and other essential habitat requirements for native resident fish species and wildlife (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to protect or rehabilitate riparian vegetation, where possible.

RATIONALE: *Healthy riparian corridors along creeks, sloughs, and channels, including those in the Colusa Basin Ecological Management Unit, provide essential cover, shade, and food for spawning, rearing, and migrating native resident fishes, and a wide variety of wildlife, neotropical birds, and other terrestrial species.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of Stony, Elder, and Thomes creeks and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 111,285 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Convert agricultural lands in the Colusa Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1C: Defer fall tillage on rice fields in the Colusa Basin Ecological Management Zone to increase the forage for wintering waterfowl and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large,

ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980).

REDUCING OR ELIMINATING STRESSORS

CONTAMINANTS

TARGET 1: Reduce the adverse effects of herbicides, pesticides, fumigants, and other agents that are toxic to fish and wildlife in the Colusa Basin Ecological Management Zone (◆).

PROGRAMMATIC ACTION 1A: Work with local agricultural interests and water districts implement and evaluate a contaminant effects study.

RATIONALE: *Contaminants from point and nonpoint sources affect water quality and survival of fish, waterfowl, and the aquatic foodweb. Contaminants may cause severe toxicity and organism mortality or long-term, low-level toxicity that affects species' health and reproductive success.*

INVASIVE RIPARIAN AND MARSH PLANTS

TARGET 1: Eradicate Arundo and tamarisk in watersheds where they have only small population, then concentrate on eradicating satellite populations extending beyond major infestations, and finally, reduce and eventually eliminate the most extensive populations.

PROGRAMMATIC ACTION 1A: Develop a cooperative pilot study to control Arundo (false bamboo) and tamarisk (salt cedar) in streams within the Colusa Basin Ecological Management Zone.

RATIONALE: *Invasive riparian and marsh plants have become sufficiently established in some locations to threaten the health of the Bay-Delta ecosystem. The riparian and salt marsh plants that pose the greatest threats to aquatic ecosystems are those that directly or indirectly affect rare native species, decrease foodweb productivity, and reduce populations of desired fish and wildlife species.*

Factors that relate to the degree of influence invasive riparian and salt marsh plants have on the Bay-Delta include additional introductions from gardens and other sources, and ground disturbances and hydrologic regimes that create favorable conditions for their establishment.

The effects of Arundo's ability to alter ecosystem processes may be profound. It is far more susceptible to fire than native riparian species. However, although it recovers from fires, most native vegetation does not, leading to increased postfire dominance by Arundo. By increasing sedimentation after establishing in stream channels, Arundo stabilizes islands, hinders braiding and shifting patterns in stream channel movement, and prevents native stream channel vegetation from establishing. An example of this can be seen at Stony Creek in northern California. Because Arundo has a vertical structure, it does not overhang water like native riparian vegetation. The result is less shade over water, providing less cover, increased water temperatures, and altered water chemistry, all conditions that can harm fish and other existing aquatic organisms and ultimately change the aquatic species composition.

Tamarisk is widespread in California rivers; however, an accurate assessment of the extent and rate of spread of the weed is unknown. Like Arundo, more survey mapping is needed to determine the extent of tamarisk, the levels of threat posed by the weed, the best time to safely control it, and a prioritized strategy for removing it.

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◆ BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

INTRODUCTION

The ecological health of the Bay-Delta depends on ecological processes and functions, habitats, and fish and wildlife species present in Butte Basin Ecological Management Zone streams, wetlands, and floodplains. The status and abundance of spring-run chinook salmon and steelhead trout are important measures of the health, not only of the Sacramento-San Joaquin River Delta, but also of the Butte Basin. The Butte Basin Ecological Zone supports the Delta ecosystem through significant contributions of streamflow, sediments, and other attributes.

The Butte Basin Ecological Management Zone provides habitat for a wide variety of fish, wildlife, and plant communities and habitats. These include spring-run chinook salmon, steelhead trout, resident fish communities, waterfowl, riparian vegetation, and seasonally and permanently flooded wetlands. The Butte Sink contains important refuge areas including Gray Lodge Wildlife Area, Butte Basin Wildlife Area, Butte Sink National Wildlife Refuge, and the Butte Sink Wildlife Management Area.

Important ecological processes and functions in the Butte Basin Ecological Management Zone include the annual streamflow and storm runoff patterns, sediment supply and gravel recruitment, and stream meander in each stream's watershed. These important processes are in a reasonably healthy condition throughout the ecological management zone, but specific improvements are needed in certain watersheds. The greatest need is to maintain processes closely linked to the natural streamflow regime. Continued efforts toward improving low flows and reducing physical barriers to fish migration will improve the overall ecological health of the watersheds in the basin while contributing to species restoration.

Photo © California Department of Water Resources

Important fish and wildlife resources in the basin include spring-run chinook salmon, fall-run chinook salmon, steelhead trout, resident fish guilds, waterfowl guilds, shorebird and wading bird guilds, and riparian wildlife guilds. Generally, the wildlife populations are healthy. Spring-run chinook and steelhead, however, need to achieve higher sustainable annual population levels before they are considered healthy and no longer a problem in the Delta. Achieving healthy status for these fish populations is also dependent on implementing restoration actions downstream of this ecological management zone.

Important habitats in the Butte Basin Ecological Management Zone include anadromous fish migration, holding, spawning, and nursery habitats (freshwater and essential fish habitats), which are needed to maintain spring-run chinook and steelhead and other chinook populations. Seasonally flooded wetlands are prevalent through the lower portions of the basin and are extremely important habitat areas for waterfowl, shorebird, and wading bird guilds. Riparian and riverine aquatic habitat is important to aquatic and terrestrial species. Woody debris, such as tree branches and root wads, provide important cover for young fish. Healthy riparian vegetation provides a migration corridor that connects the mainstem Sacramento River with habitats in the

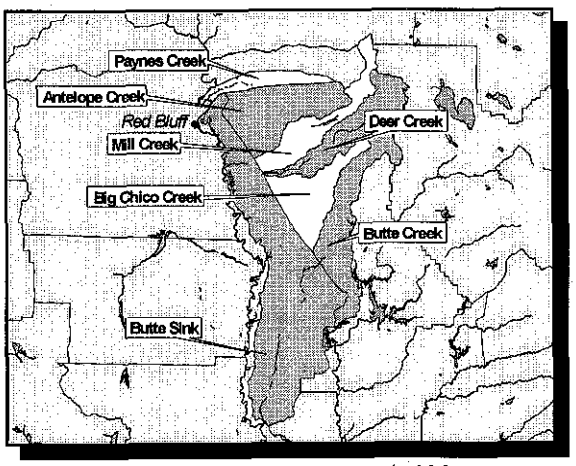
upper watershed. This corridor is used by terrestrial species, such as birds and mammals.

Stressors to ecological processes, habitats, and species in the zone include diversion structures in the streams; unscreened diversions; insufficient flow in the lower portions of most of the streams, which may seasonally inhibit the upstream and downstream migration of anadromous fish; areas of inadequate riparian vegetation and woody debris; and the potential illegal harvest of spring-run chinook salmon that oversummer in isolated pools in many of the streams.

DESCRIPTION OF THE MANAGEMENT ZONE

The Butte Basin Ecological Management Zone encompasses a significant portion of the Sacramento Valley, east of the Sacramento River and north of the Colusa Basin Ecological Management Zone, and includes the following seven ecological units:

- Paynes Creek Ecological Unit,
- Antelope Creek Ecological Unit,
- Mill Creek Ecological Unit,
- Deer Creek Ecological Unit,
- Big Chico Creek Ecological Unit,
- Butte Creek Ecological Unit, and
- Butte Sink Ecological Unit.



Location Map of the Butte Basin Ecological Management Zone and Units

LIST OF SPECIES TO BENEFIT FROM RESTORATION ACTIONS IN THE BUTTE BASIN ECOLOGICAL MANAGEMENT ZONE

- fall-run chinook salmon
- spring-run chinook salmon
- steelhead trout
- lamprey
- native anuran amphibians
- native resident fishes
- neotropical migratory birds
- giant garter snake
- waterfowl
- plants and plant communities.

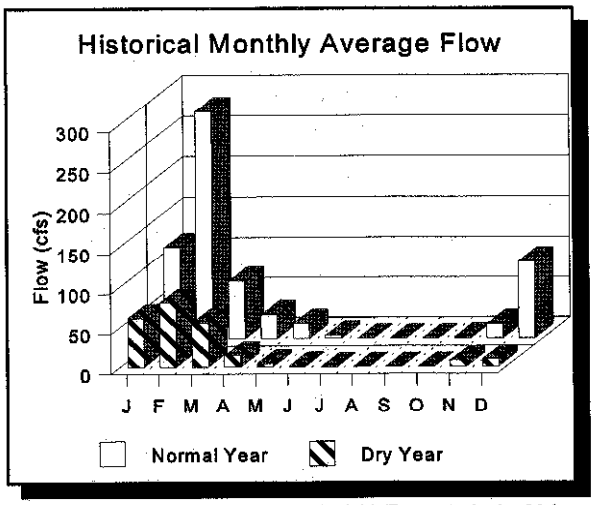
DESCRIPTIONS OF ECOLOGICAL MANAGEMENT UNITS

PAYNES CREEK ECOLOGICAL MANAGEMENT UNIT

Paynes Creek enters the Sacramento River 5 miles north of Red Bluff. It flows into the Sacramento Valley from the east, draining a watershed of approximately 93 square miles. Paynes Creek originates in a series of small lava springs approximately 6 miles west of the town of Mineral. There are no significant dams on the stream; however, as many as 16 diversions seasonally divert water. Diverted water is used for irrigation, stock watering, and commercial aquaculture. Diversions are confined to the period between late spring and early fall. Significant losses of juveniles can occur in spring if the irrigation season begins when juvenile salmon are attempting to emigrate from the stream into the Sacramento River. Approximately 15 diversions in Paynes Creek need to be screened to protect juvenile fish.

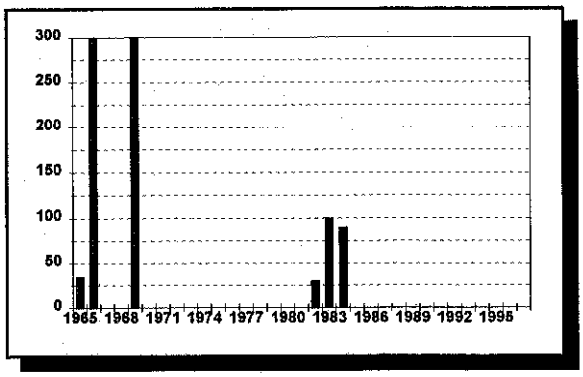
Paynes Creek has a natural flow pattern of high winter and low summer-fall flows, typical of many Sacramento Valley streams that originate in

foothills rather than the crests of the Sierra Nevada or Cascade ranges. Low summer and fall flows are further reduced by diversions. The stream is often dry during summer and fall. In wetter years, flows in winter average 200 to 600 cfs. In winter months of dry years, average monthly flows peak at only 50 to 80 cfs. In the driest years, winter monthly average flows reach only 10 to 20 cfs.



Paynes Creek Streamflow, 1956-1966 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall-run chinook salmon and steelhead trout use Paynes Creek when streamflow is sufficient to allow upstream passage. Surveys in the 1960s documented an average run size of 143 fall-run salmon; 300 fish was the maximum run observed in a single season. In most years, rainfall provides sufficient flow for the fall-run chinook salmon to move upstream by late fall.



Fall-run Chinook Salmon Returns to Paynes Creek, 1965-1997.

Riparian and riverine aquatic habitat needs to be improved by providing adequate streamflows and by protecting shorelines from livestock. Vegetation planting may be required in certain areas to hasten and sustain a riparian corridor along the stream.

The size of the salmon run in Paynes Creek is closely linked to rainfall. Therefore, actions to restore and improve conditions for chinook salmon and steelhead are more likely to succeed during periods of normal to above normal rainfall. Limiting water diversions during critical migration periods would help to maintain and improve flows. Reduced diversions could be achieved through voluntary restrictions; direct water purchase; or development of alternative sources, such as wells or storage facilities. Adequate flows are needed in Paynes Creek to provide for the fall adult migration, winter season fry rearing, and spring juvenile outmigration in drier years. Minimum flows in upstream summer rearing areas are needed to sustain steelhead.

In addition to low flow, inadequate spawning gravel has been identified as a significant factor limiting salmon production. The California Department of Fish and Game (DFG) built five spawning riffles with 1,000 tons of spawning gravel in 1988. Improvement to the sediment supply, including gravel for fish spawning, needs further evaluation.

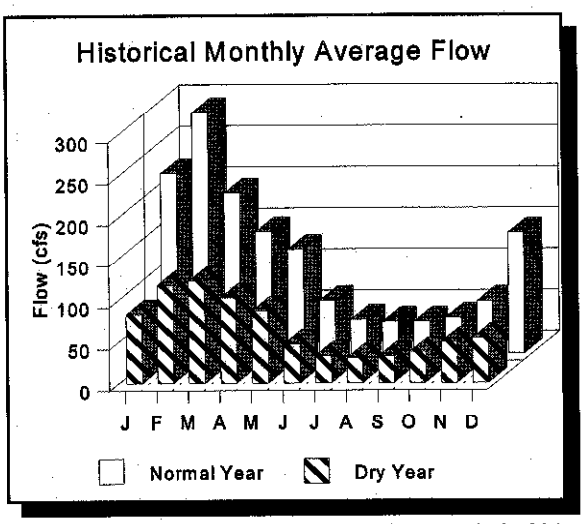
Restoration and maintenance of Paynes Creek could be improved by establishing a Paynes Creek watershed conservancy. Restoring and maintaining Paynes Creek could be facilitated by developing and implementing a comprehensive watershed management plan.

ANTELOPE CREEK ECOLOGICAL MANAGEMENT UNIT

Antelope Creek flows southwest from the Cascade Range foothills and enters the Sacramento River 9 miles southeast of Red Bluff. The drainage is approximately 123 square miles, and the average

stream discharge is 107,200 acre-feet (af) per year. Antelope Creek is relatively unaltered above the valley floor, but the seasonal lack of flow to the Sacramento River reduces the creek's potential to produce anadromous fish.

Antelope Creek has a natural streamflow pattern like other nondammed streams in this ecological



Antelope Creek Streamflow, 1942-1982 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

management zone. Peak flows occur in winter and spring. Lowest flows occur in summer and fall. In wettest years, average flows in winter months range from 200 to 1,200 cfs. In driest years, flows in winter months average below 50 cfs. In all but the wettest years, summer and early fall flows average from 20 to 50 cfs. The natural flow pattern is altered by diversions in the lower creek from spring through fall.

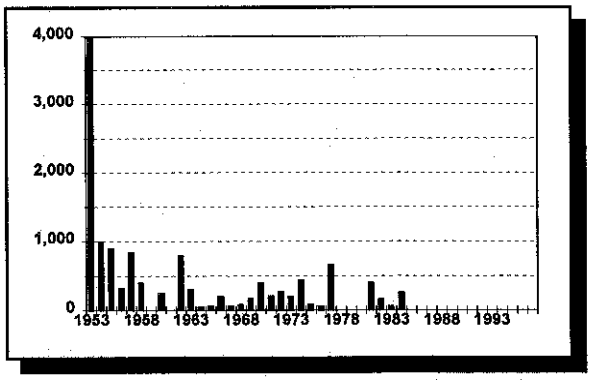
There are two water diversions at the canyon mouth on Antelope Creek. The Edwards Ranch uses water from both diversion points under riparian and pre-1914 water rights. The Los Molinos Mutual Water Company (LMMWC) shares one diversion with a water right of 70 cfs. Antelope Creek flow is typically diverted from April 1 through October 31. Average flow during this period, measured from 1940 through 1980, was 92 cfs. With water diversion rights exceeding streamflow, the lower reach of the stream is often dry. The seasonal flow needs improvement to permit unobstructed fish passage. To reestablish and increase salmon and steelhead in Antelope Creek, priority must be given to providing and maintaining adequate passage flows from October 1 through June 30 below the Edwards and LMMWC diversion dam. Diversions on Antelope Creek have been screened to protect juvenile salmon and steelhead during their downstream passage.

Migration flows and temperatures adequate to attract salmon must be provided at Antelope Creek's confluence with the Sacramento River. Diversions during the chinook and steelhead migration season should be limited to maintain a flow of at least 25 cfs at the mouth of Antelope Creek. Instream flows should be maintained throughout the irrigation diversion season to provide aquatic habitat and riparian vegetation benefits.

The riparian and riverine aquatic habit along the Antelope Creek corridor needs several improvements. Some areas have been denuded and will require significant revegetation. Woody debris, such as branches and root wads originating from the riparian forest, provides valuable cover for young fish. The riparian zone provides an important migratory corridor for terrestrial species by connecting the mainstem Sacramento River with upper watershed habitats.

Fall- and spring-run chinook salmon and steelhead trout have used Antelope Creek. Population estimates for fall-run salmon on Antelope Creek from 1965 through 1984 ranged from 50 to 4,000, with an average annual run of approximately 467 fish. Historically, an estimated 500 spring-run chinook salmon and approximately 300 steelhead trout annually used Antelope Creek. Since 1986, the California Department of Fish and Game has conducted intensive snorkle surveys on Antelope Creek. Over a period of 12 years, a total of only 19 spring-run chinook salmon have been

observed. During 1997, no adult spring-run chinook salmon were observed. This series of observations suggest that Antelope Creek no longer supports a self-sustaining population of chinook salmon. The status of steelhead in Antelope Creek is unknown.



Fall-run Chinook Salmon Returns to Antelope Creek, 1953-1997.

The overall role of Antelope Creek in supporting viable populations of anadromous fish is strongly constrained by flow patterns, flow quantity, high water temperatures, geomorphology of the valley section of the stream, and the steep gradient in the upper reaches.

Insufficient fall flow patterns may delay the upstream migration and spawning of adult fall-run chinook and downstream migration of juvenile spring-run chinook. Likewise, inadequate late spring flows may limit part of the spring-run upstream migration and downstream juvenile fall-run chinook migration. In the lower stream section below the canyon mouth, Antelope Creek is subject to braiding and channel bifurcation, which also impair upstream fish passage.

The Antelope Creek Ecological Unit could be improved by establishing and supporting an Antelope Creek watershed conservancy. Restoring and maintaining Antelope Creek could be improved by developing and implementing a comprehensive watershed management plan. Forest management, including reducing fire fuel loads, would protect riparian habitats and stream-flows and help to prevent excessive sediment from being washed into the creek.

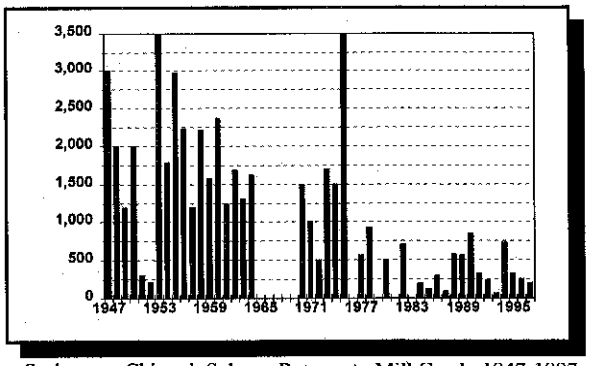
Mill Creek Ecological Management Unit

Mill Creek is a major tributary of the Sacramento River, flowing from the southern slopes of Mt. Lassen and entering the Sacramento River at river mile (RM) 230, 1 mile north of the town of Tehama. The stream originates at an elevation of approximately 8,500 feet and descends to 200 feet at its confluence with the Sacramento River. The watershed drains 134 square miles, and the stream is approximately 65 miles long. The creek is confined within a steep-sided, relatively inaccessible canyon in the upper watershed. Mill Creek spring-run chinook salmon are unique, because they spawn at altitudes above 5,000 feet—the highest altitudes known for salmon spawning in California. The stream flows through the Ishi Wilderness Area and the Gray Davis Dry Creek Reserve, which is managed by The Nature Conservancy. Two dams on the lower 8 miles of the stream divert most of the natural flow for irrigation purposes, usually from May and until September.

Mill Creek has a somewhat atypical seasonal flow pattern. Flows remain relatively high through spring, even in dry years, because of snowmelt and springs on Mt. Lassen. In wettest years, average monthly flows in winter and spring range from 800 to 1,800 cfs. In driest years, flows range only from 60 to 120 cfs. With no storage reservoirs and minimal diversions on the river, streamflows are near natural and unimpeded, except in the valley lowland reach.

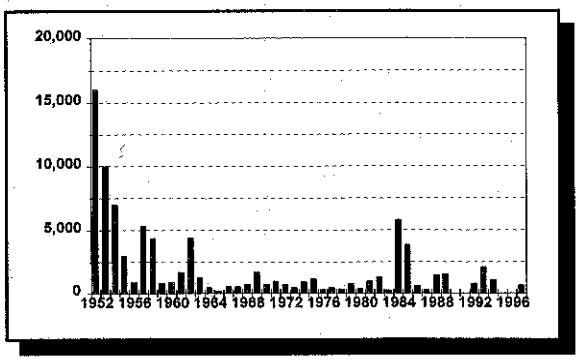
The ecological health of the Mill Creek ecological unit is rated above average due to unimpeded stream flow and the undisturbed quality throughout the holding and spawning habitat of spring-run chinook salmon and steelhead. Populations of spring-run chinook salmon and steelhead have declined sharply in recent years, in large part due to problems outside of the unit.

Spring-run chinook salmon populations in Mill Creek have ranged from a maximum of 3,500 fish to a low of no fish during the severe drought of 1977. During the past decade, annual spring-run chinook populations have averaged 390 fish. More than 2,000 steelhead have been counted at Clough Dam, and steelhead runs averaged 1,100 fish from 1953 to 1965. Anecdotal accounts place the present annual steelhead population at a few hundred fish.



Spring-run Chinook Salmon Returns to Mill Creek, 1947-1997

Fall-run chinook salmon population estimates have ranged from approximately 6,000 spawners in 1984 to 150 in 1965. The fall run has averaged 2,200 fish for the 38 years of record. Late-fall-run salmon have occasionally been observed spawning in the lower reaches of Mill Creek, but no estimates are available.



Fall-run Chinook Salmon Returns to Mill Creek, 1952-1997.

Mill Creek differs from other eastside streams because of its high silt load and turbidity during the spring snowmelt period. Recent water quality monitoring for Mill Creek indicates that lands within Lassen Volcanic National Park contribute the major source of silt from the steep barren slopes adjacent to the headwaters. There are insignificant land use activities that occur on the Lassen National Forest lands, however, most of the area is protected by its wilderness designation. The majority of the siltation sources in Mill Creek are the result of natural geologic processes that have existed for thousands of years and are not an impediment to the survival of the endemic anadromous fish populations.

Spawning areas in lower Mill Creek consist primarily of large cobbles and boulders, with very little spawning gravel. Spawning gravel naturally accumulates in the lower reaches of the stream but is flushed from the stream during higher flow events.

Three diversion structures were constructed on Mill Creek in the early 1900s, however, only two are operational. The upper and lower diversions are low structures and have been screened since the 1920s. The Department of Fish and Game has completed several improvements to these structures over the past 50 years including the addition of fish ladders and resloping and refacing the surface of the structures to improve fish passage. These diversion structures are owned and managed by the Los Molinos Mutual Water Company and are regularly inspected by the Department of Fish and Game to insure optimum fish passage conditions.

The middle diversion structure is known as the Clough Diversion which was constructed in the early 1920s and is privately owned. The structure was screened and has a functional fish ladder. The Clough Dam was breached during the January 1997 flood and presently is not a barrier to fish passage. Alternative designs for reconstructing the dam include options to provide water for irrigation without impairing fish passage.

All of the water diversions have screens, owned by the DFG, in place and in good operating condition.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. One of the key elements in restoring Mill Creek's salmon and steelhead populations is obtaining dependable flow in the lower stream reaches. A negotiated agreement with the water users is the preferable means of achieving this goal, because it would minimize conflicts between historical land uses and restoration of salmon and steelhead habitat. This has been partially achieved through a cooperative water exchange agreement which has been in place for seven years.

The riparian corridor needs improvement in several areas. Some locations have been denuded and will require significant revegetation.

Gravel spawning habitat in the valley floor section of the creek is not adequate for fall-run chinook salmon. Gravel recruitment is limited because of a relatively low natural supply attributable to the geologic features in the basin. Existing gravel sources may be enhanced to improve spawning areas for fall-run chinook salmon. An evaluation of the potential benefits of providing supplemental gravel into the channel should be completed.

Conservation, restoration, and preservation efforts on Mill Creek have been established by the Mill Creek Conservancy which supports the local approach to watershed management. The local residents, concerned citizens, and resource agencies worked together and prepared the Mill Creek Watershed Management Strategy which is a comprehensive document containing specific recommendation for resource protection.

Restoration activities are presently being implemented in accordance with the priorities stated in the Mill Creek Watershed Management Strategy. The Strategy Report addresses potential stressors including the potential adverse impacts from timber harvesting and additional recreational activities. However, the majority of the upper and middle watershed is protected from detrimental activity due to its Wilderness designation, PACFISH regulations, and private conservation easements.

The majority of the Mill Creek watershed remains undisturbed and is still capable of supporting historic runs of salmon and steelhead. Potential restoration work is concentrated in the lower watershed area on the valley floor that has been impacted by human activities. The major restoration efforts include replanting native riparian vegetation and securing additional instream flows.

Potential timber harvest in the upper watershed threatens loss of holding and spawning areas due to habitat degradation. Selective harvest and well-planned road construction would minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

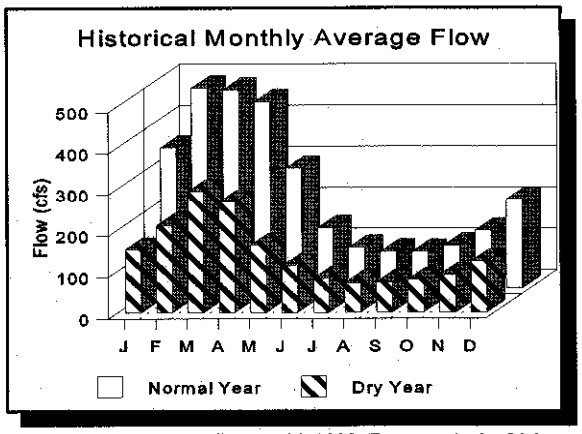
Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to illegal harvest. The remoteness of the spawning areas contributes to enforcement problems.

DEER CREEK ECOLOGICAL MANAGEMENT UNIT

Deer Creek is a major tributary to the Sacramento River, originating upstream of Deer Creek Meadows on the slopes of Butt Mountain. The creek enters the Sacramento River approximately 1.5 miles north of Woodson Bridge State Park. The watershed drains 200 square miles and is 60 miles long. Part of the upper stream is paralleled by State Highway 32. The lower 10 miles of the creek flow through the valley, where most of the flow is diverted. This lower section encompasses a relatively large flood plain bounded on either side by levees.

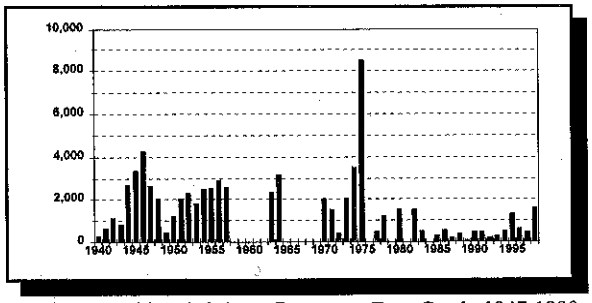
In many years prior to 1990, three diversion dams and four diversion ditches depleted all of the natural flow from mid-spring to fall. Since 1990, the local irrigation districts, with assistance from the Departments of Fish and Game and Water Resources, have voluntarily provided fish passage flows at critical times. All of the diversion structures have fish ladders and screens. Of all Sacramento Valley streams, Deer Creek has the greatest potential for restoring spring-run chinook salmon. Overall, the ecological health of the Deer Creek Ecological Management Unit is rated above average. Although spring-run chinook salmon and steelhead populations need to increase in size, the factors limiting these populations lie primarily outside of the unit.

Deer Creek has a seasonal flow pattern similar to that of Mill Creek. Flows are highest in winter and spring, and summer and fall flows. Peak monthly flows in wet winters reach up to 2,600 cfs. In driest years, winter flows reach only 90 to 110 cfs. Minimum summer and fall base flows are 60 to 80 cfs.

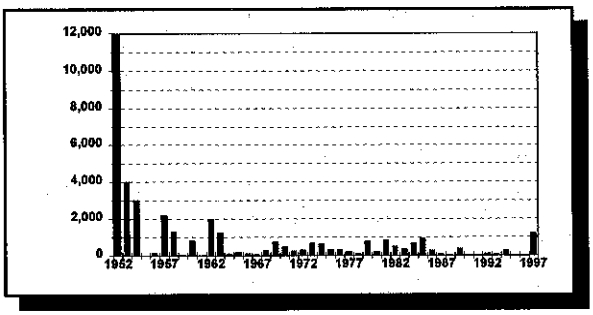


Deer Creek Streamflow, 1923-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout use Deer Creek. During the past decade, an average of approximately 550 spring-run and 1,000 fall-run chinook have spawned annually in Deer Creek. Habitat in the upper watershed is relatively intact, with numerous holding areas and an abundance of spawning gravel. Some spawning areas in lower Deer Creek are lightly armored and could limit production of fall-run chinook salmon.



Spring-run Chinook Salmon Returns to Deer Creek, 1947-1998.



Fall-run Chinook Salmon Returns to Deer Creek, 1952-1997.

Except for the lack of streamflows on the valley floor below the agricultural diversions, fish habitat throughout the drainage is generally of good quality. Water right holders on Deer Creek have recently expressed interest in developing alternative water sources for fishery flows. Water users are concerned about the depleted status of the spring-run chinook salmon and have been working toward mutually acceptable solutions to restore the fishery.

Sufficient flows permit unobstructed fish passage and cleanse and distribute new spawning gravels. Inadequate flow for upstream passage is the most significant problem on Deer Creek. Flows necessary to provide unimpaired migration in the lower stream section for adult salmon and steelhead are undetermined but have been estimated to be 50 cfs at a minimum.

Adequate spawning gravel is found in lower Deer Creek for present population levels of fall-run salmon and existing gravel sources should be

protected. Prior to any effort to supplement existing gravel supplies, a comprehensive analysis of stream channel dynamics is required. This study should include elements that address geomorphology, sediment transport flows, stream channel meander, sediment sources, and flood control needs or requirements.

Restoration efforts on Deer Creek will involves the ongoing participation and support of local landowners through the Deer Creek Conservancy, a local landowners organization. One role of the Deer Creek Conservancy has been the successful development of a cooperative watershed management plan including a watershed management strategy (Deer Creek Watershed Conservancy 1998). Plan formulation is in process and will help to preserve and restore spring-run chinook salmon and steelhead trout and other important attributes of the watershed. The ecological health of Deer Creek could be maintained by developing and implementing a comprehensive watershed management plan.

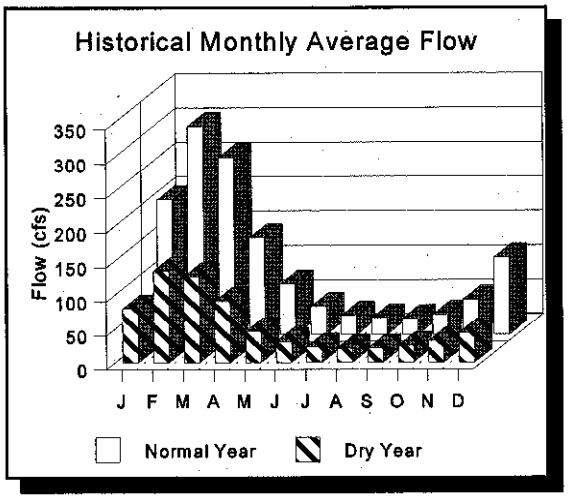
Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs protection and improvement in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning area contributes to enforcement problems.

Big Chico Creek Ecological Management Unit

Big Chico Creek enters the Sacramento River 5 miles west of the City of Chico. It flows into the Sacramento Valley from the Sierra Nevada foothills, draining a watershed of approximately 72 square miles. There are no significant impoundments on the stream, and the only major water diversion has been relocated to the mainstem Sacramento River. The stream is the focal point of the local Chico community. The creek flows through Bidwell Park, downtown Chico, and the Chico State University campus. (Bidwell Park is the third largest city park in the nation.) Lindo Channel is an element of the local flood control system and originates at the Five Mile Recreation Area. The channel returns water to the creek near its mouth below the City of Chico.



Big Chico Creek Streamflow, 1936-1986 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

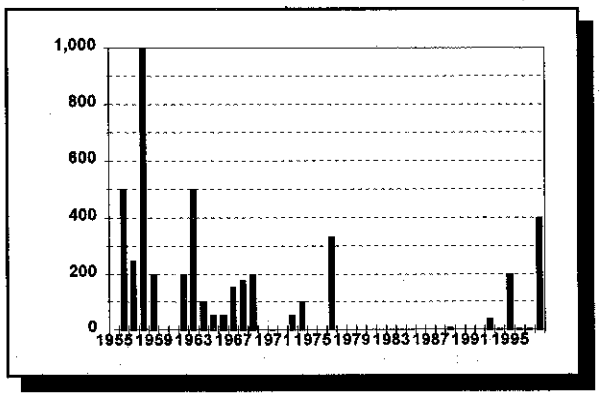
Big Chico Creek has a seasonal flow pattern similar to that of Antelope Creek with moderate winter flows and lower late spring to early fall flow than Mill and Deer Creeks. Peak winter month average flows reach 600-1,500 cfs. In driest years, winter flows reach only 20-40 cfs.

Minimum summer and fall base flows are 15-20 cfs in all but the wettest years.

Important resources in Big Chico Creek include spring- and fall-run chinook salmon and steelhead trout and resident native fishes. Although spring-run chinook salmon and steelhead populations are very low, factors limiting these population lie primarily outside of the unit. Some improvements in the steelhead trout and spring-run chinook salmon populations can be made if habitat and flows can be restored.

In 1958, the spring-run chinook salmon population was estimated at 1,000 adults, although the average annual run was probably less than one-half this amount during the 1950s and 1960s. An estimated 400 spring-run returned to Big Chico Creek in 1998 in response to a series of wet years and the relocation of the M&T Pumping Station to the mainstem Sacramento River. Steelhead populations are thought to have averaged approximately 150 returning adults during this same period. Recent estimates indicate only a remnant spring-run chinook population, a low steelhead population, and a highly variable spawning population of fall-run chinook salmon. In addition, adult spring-run chinook are deterred by intermittent flow in Lindo Channel and inadequate fish passage at the One and Five Mile Recreation Areas and at Iron Canyon in upper Bidwell Park. Marginal spawning and rearing habitat in Big Chico Creek and Lindo Channel below the Five Mile Recreation Area is used by fall-run chinook salmon. Big Chico Creek and Lindo Channel are used by many interests for a variety of purposes, including wildlife habitat, anadromous fisheries reproduction and rearing, urban storm drainage, flood control, and recreation.

Functioning in the flood control and recreational pool system, the ecological system supports three salmonid runs. Without careful coordination, successful management of one use may conflict with successful management of another. Even though excellent spawning gravel exists in Lindo



Spring-run Chinook Salmon Returns to Big Chico Creek, 1956- 1998.

Channel, in most years, intermittent flows preclude successful spawning. Big Chico Creek flows for nearly 11 miles through the City of Chico, much of it through Bidwell Park. Vegetation along Big Chico Creek in Bidwell Park is an excellent example of a mature riparian community. Lindo Channel functions as a flood relief channel for Big Chico Creek and supports riparian habitat. Both are surrounded by urban and agricultural uses that could degrade their environmental quality.

Inadequate flow for upstream passage is the most significant problem on Big Chico Creek. During all but the wetter years, flows in fall remain at summer lows. This inhibits and delays the upstream fall-run chinook salmon migration. Water management operations, such as the flow split at Five Mile Diversion Dam, that can improve flows for passage should be evaluated.

Gravel recruitment is limited by existing diversion dams, or gravel is in poor supply from past floods or flood control practices. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

Restoration efforts on Big Chico Creek will involve the participation and support of local landowners through the Big Chico Creek Task Force, a local organization of stakeholders. The Big Chico Creek Task Force will be instrumental in developing a comprehensive watershed

management plan and will assist or sponsor some of the needed restoration elements in the basin. One role of the Big Chico Creek Task Force will be to sponsor the development of a cooperative watershed management plan that will assist in the effort to preserve and restore spring-run chinook salmon and steelhead trout.

The ecological health of the creek could be improved by developing and implementing a comprehensive watershed management plan. Timber harvest in the upper watershed could threaten loss of holding and spawning areas because of habitat degradation. Selective harvest and well-planned road construction may minimize this effect. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

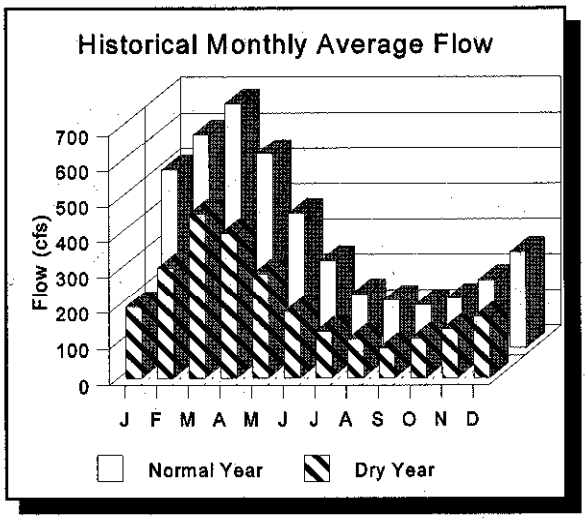
Salmon and steelhead passage problems at Iron Canyon, One-Mile Pool, and Five-Mile Diversion will be improved by repairing weirs and fishways.

Adult spring-run chinook salmon oversummering in deep upstream pools are susceptible to poaching. The remoteness of the spawning areas contributes to enforcement problems. Protect holding pools by obtaining willing seller titles or conservation easements on lands adjoining pools.

BUTTE CREEK ECOLOGICAL MANAGEMENT UNIT

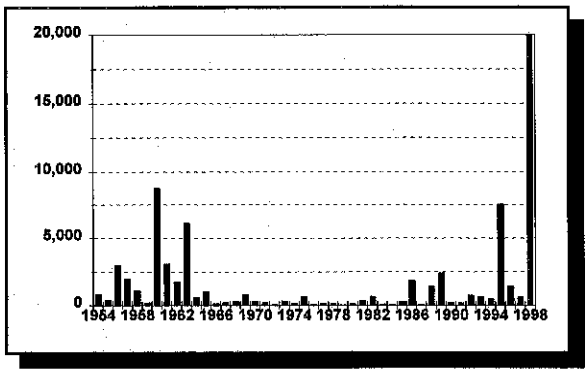
Butte Creek originates in the Jonesville Basin, Lassen National Forest, on the western slope of the Sierra Nevada. It drains the northeastern portion of Butte County. The creek enters the Sacramento Valley southeast of Chico and meanders in a southwesterly direction to the initial point of entry into the Sacramento River at Butte Slough. A second point of entry into the Sacramento River (at lower flows) is through the Sutter Bypass and Sacramento Slough. Butte Creek drains the foothills just south of the Big Chico Creek watershed and North Fork of the Feather River drainage. The upper Butte Creek watershed (northeast of Chico) has an area of approximately 150 square miles. Lower Butte Creek flows parallel to the Sacramento River for almost 50 miles to the Butte Slough outfall. It then continues through the Sutter Bypass and Sacramento Slough channels to join the Feather River near the confluence with the Sacramento River, almost 100 miles downstream of Chico. Butte Slough connects with the Sacramento River through flap gates in the Sacramento River levee. These gates may not be open during the salmon and steelhead migration periods.

Streamflow on Butte Creek is similar to that on Deer Creek, with water from snowmelt and springs to maintain summer and fall flow even in drier years. Peak flow in winter of wet years reaches 1,000 to 3,000 cfs. In driest years, winter flows average only 90 to 120 cfs. Summer and fall minimum flows generally average 120 to 160 cfs but may reach only 50 cfs in driest years.

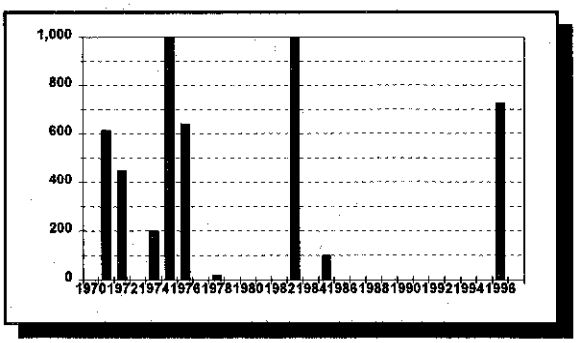


Butte Creek Streamflow, 1963-1993 (Dry year is the 20th percentile year; normal year is the 50th percentile or median year.)

Fall- and spring-run chinook salmon and steelhead trout exist in Butte Creek. As late as the 1960s, Butte Creek supported more than 4,000 adult spring-run chinook salmon, a lesser number of fall-run chinook salmon, and a small number of steelhead trout. More recently, the spring-run chinook populations have ranged from fewer than 200 adults to more than 1,000. Spring-run chinook salmon estimates reached a record of more than 8,000 in 1995, and Butte Creek demonstrated its ability to attract a large spring-run chinook salmon population with adequate streamflows. The fall-run chinook salmon population varies between a few fish to as many as 1,000. The number of steelhead is unknown.



Spring-run Chinook Salmon Returns to Butte Creek. 1954-1998.



Fall-run Chinook Salmon Returns to Butte Creek, 1970- 1997.

The decline of Butte Creek's chinook salmon and steelhead populations is attributed to:

- inadequate flows,
- unscreened diversions,
- inadequate passage over diversion dams,
- unblocked agricultural return drains that attract and strand adult fish,
- poor water quality, and
- poaching.

Nine diversion dams on Butte Creek above Butte Slough supply water for power generation, irrigation, gun clubs, and domestic use. All are known to impair and delay migrating fish. One, the Point Four Ranch Dam, was removed in July 1993. Passage at seven of the dams could be improved by either removing the dam or upgrading the ladders. All of the diversions from these dams are unscreened, except the diversion at the Parrott-Phelan Dam, which was recently screened. Presently, three of the seven dams are being removed as part of the Western Canal siphon project, and three others (Durham Mutual, Adams, and Gorrill) have defined projects to build or rebuild ladders and fish screens.

The Centerville Head Dam, immediately below the DeSabla powerhouse, is the upper limit of anadromous fish migration. Water diverted from three adjacent watersheds commingles with the natural flows of Butte Creek and often is the major portion of the flow. Feather River water enters Butte Creek at two locations: via the West Branch into DeSabla Reservoir and through the Thermalito Afterbay and the Western Canal. Flows from both Big and Little Chico Creeks enter Butte Creek from agricultural diversions that empty into Little Butte Creek. Flows from the Sacramento River reach Butte Creek from various diversion points, from as far north as the mouth of Big Chico Creek to the Reclamation District 1004 pumps located near Princeton.

Adult spring-run chinook salmon migrate into Butte Creek during February through June. They oversummer primarily in pools from the confluence of Little Butte Creek to the Centerville Head Dam and begin spawning in late September. Spring-run chinook fry emigrate as early as

December, whereas smolts emigrate the following spring. Generally, adequate migration flow exists from Centerville Head Dam downstream to the Western Canal Dam; however, during dry years, several areas above Western Canal may hinder upstream passage. In these dry years, adult spring-run chinook salmon encounter low, warm flows above Western Canal and may become stranded.

Adult fall-run chinook salmon enter lower Butte Creek during late September and early October. Their upstream passage is often blocked by dewatered stream reaches caused by diversions for flooding State and federal refuges and private duck clubs. Below the Western Canal, adult fall-run chinook often encounter impassable barriers, dewatered areas, silt deposition areas, lack of suitable gravel, and inadequate cover and shade. Several barriers exist above the Western Canal that impede the adult migration until high flows occur. Most fall-run chinook salmon spawn in the area from Durham to the Parrott-Phelan Dam, although some are known to spawn above these dams. Spawning generally occurs from October through December. Fall-run fry begin to emigrate during January and February, and smolts emigrate during April and May. However, many juveniles are entrained at the diversions or perish because of poor water quality.

Although little is known about steelhead in Butte Creek, adults probably ascend in the late fall and winter. They probably spawn during winter and spring in tributaries, such as Dry Creek, and the mainstem creek above Parrott-Phelan diversion.

The water allocation problems in the lower Butte Creek system need to be reduced. The diversion of water for agriculture, waterfowl refuges, and seasonally flooded wetlands should not impair efforts to rebuild salmon and steelhead stocks. Butte Creek water management is extremely complex. Maintaining adequate fishery flows will require close coordination among all water users in the basin. Extension of State Watermaster Service into the lower reach of Butte Creek should be considered to fulfill these management goals. This extension, however, requires the State Water Resources Control Board to adjudicate water below the Western Canal siphon. The area above is adjudicated. State Watermaster Service presently exists down to Western Canal. Extension of this service below Western Canal would require adjudication of the remaining water rights. Wildlife refuges and hunting clubs dependent on Butte Creek water provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley. The timing of water needs conflicts among duck clubs, agriculture, and the anadromous fisheries .

Seasonal flooding of refuges and duck clubs conflicts with flows needed for spawning fall-run chinook salmon. Rice field irrigation overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May. Evaluating and determining water rights, water use, and instream flow needs will be a long-term effort requiring the involvement of irrigation districts, private landowners, and agency personnel. Rebuilding salmon runs in Butte Creek will require a negotiated balance among wildlife, agriculture, and fishery needs. Flow improvements can be gained by providing minimum flow requirements below diversions and acquiring existing water rights from willing sellers.

It is generally believed that gravel recruitment in the upper sections is not affected by existing diversion dam since they are either seasonal agricultural dams or relatively low-head hydropower dams which have not had major impacts on gravel recruitment of sediment supply. Existing gravel sources should be protected and supplemental gravel placed into the creek channel as needed.

The Butte Creek Watershed Conservancy is an important organization in developing, evaluating, and implementing measures to improve the ecological health of Butte Creek. This conservancy comprises local stakeholders who work closely with federal and State resource agencies to maintain and restore habitats along the creek. The

Butte Creek Watershed Conservancy will be instrumental in developing a comprehensive watershed management plan. It will assist or sponsor some of the needed restoration elements in the basin, including improving streamflows for gravel recruitment and fish passage. The management plan will help to preserve and restore spring-run chinook salmon and steelhead trout. The ecological health of the creek also could be improved by developing and implementing a comprehensive watershed management plan. Current timber harvest in the upper watershed is generally not a threat to chinook salmon or steelhead holding and spawning areas. Maintaining the existing harvest and well-planned road construction will minimize any future effects. Additional recreation areas must be carefully planned and implemented to preserve existing fish habitat. Forest management, including reducing fire fuel loads, will protect riparian habitats and streamflows and help to prevent excessive sediment from being washed into the creek.

The riparian corridor needs to be protected and improved in the lower and upper river. In the lower river, riparian habitat improvements will be coordinated with flood control management activities in cooperation with local landowners.

Salmon and steelhead passage will be provided at diversion dams, including Western Canal, Durham Mutual, Adams, Gorrill, McGowan, and McPherrin. In some cases, dams will be removed. In others, fish ladders will be constructed or upgraded. Migration into lower Butte Creek via Butte Slough and the Sutter Bypass is the present means for salmon and steelhead passage to and from Butte Creek. Gates on the Sacramento River at the head of Butte Slough could be modified and operated to allow year-round passage of both juveniles and adult fish. There may also be improvements in the operation of weirs and diversions in the Sutter Bypass channels that will improve the survival of salmon and steelhead.

BUTTE SINK ECOLOGICAL MANAGEMENT UNIT

The Central Valley is one of the most important waterfowl wintering areas in the Pacific Flyway. In recognition of the value of waterfowl throughout North America, the Central Valley Habitat Joint Venture was formed to protect and restore wetlands in the Central Valley. The Butte Sink is one of the important elements of this venture. There are 11,363 acres of publicly owned and managed waterfowl habitat in the area, including the Butte Sink National Wildlife Refuge (733 acres), Gray Lodge Wildlife Area (8,375 acres), Upper Butte Sink unit of Gray Lodge (3,750 acres). The Gray Lodge WA is natural habitat in complex of wetlands and associated uplands whereas the Upper Butte Sink Unit and Butte Sink NWR are mostly agricultural land that will be restored to natural habitat. Hunting clubs maintain more than 30,000 acres of habitat in a normal year. Of this total, about 18,000 acres are natural wetlands and 12,000 acres are harvested rice fields flooded for hunting. Currently, 5,350 acres of private duck clubs are permanently protected by USFWS Conservation Easements in the Butte Basin. The National Audubon Society owns and manages another 500 acres of wetlands at the Paul L. Wattis Audubon Sanctuary west of Butte Creek (Central Valley Habitat Joint Venture 1990).

The area is also seasonally important for salmon and steelhead passage between the Sacramento River and holding, spawning, and rearing areas of the creeks. The sink is predominately wetlands interspersed with riparian vegetation all of which is subject to frequent natural seasonal flooding, which are major reasons for its importance to fish and wildlife, particularly waterfowl.

VISION FOR THE ECOLOGICAL MANAGEMENT ZONE

The vision for the Butte Basin Ecological Management Zone includes restoring important fishery, wildlife, and plant communities to health. Generally, health will be attained when the status of specific biological resources is no longer a problem in the Delta. To attain this vision, this program will seek to improve streamflow and riparian corridors, screen diversions, remove barriers to fish migration, and restore watershed health through improved forest and rangeland management.

The vision for the Butte Basin Ecological Management Zone focuses on restoring physical processes and habitats and reducing stressors to meet spring-run chinook salmon and steelhead population levels of the late 1960s and early 1970s. In addition, improvements in the riparian corridors will provide improved habitat for waterfowl and other wildlife. The program proposes targets and actions that will increase protection for naturally produced chinook salmon and steelhead as they rear and migrate to the mainstem Sacramento River. Important actions to improve survival include maintaining and restoring a healthy riparian zone, which includes ample shaded riverine aquatic (SRA) habitat, woody debris, and biologically productive gravel beds for fish spawning and invertebrate production. The vision also anticipates screening many small water diversions and providing sufficient flows during important periods of adult migration and juvenile emigration.

The Ecosystem Restoration Program Plan (ERPP) recommends the following approaches for restoring the Butte Basin Ecological Management Zone.

VISIONS FOR ECOLOGICAL MANAGEMENT UNITS

PAYNES CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Paynes Creek Ecological Unit is to improve steelhead trout and fall-run chinook salmon populations by improving streamflows and gravel spawning habitat. Paynes Creek can make minor but important contributions to the upper Sacramento River runs of these fish if adequate holding, spawning, rearing, and migration habitat are provided. Adequate streamflows are important for maintaining and restoring the connectivity of upstream spawning and nursery areas with the mainstem Sacramento River. Sufficient flows must be provided to cleanse and distribute new spawning gravels. The riparian corridor needs significant improvement in several areas; some have been denuded and will require significant revegetation.

ANTELOPE CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Antelope Creek Ecological Unit is to increase its ability to make small contributions to chinook salmon and steelhead populations by improving fall and spring flows, increasing spawning gravels and restoring riparian corridors. The health of Antelope Creek will be maintained so that it can provide seasonal inflow, sediments, and nutrients to the Sacramento River. Antelope Creek will provide important migratory corridors for aquatic and terrestrial species. Antelope Creek could be important in some years for salmon and steelhead with adequate flows and improved spawning and rearing habitat.

MILL CREEK ECOLOGICAL MANAGEMENT UNIT

Mill Creek is an important ecological unit in the Butte Basin Ecological Management Zone. It provides valuable habitat for anadromous and

native resident fish. The vision for the Mill Creek Ecological Unit is to increase spring- and fall-run chinook salmon and steelhead by maintaining adequate streamflows, restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program, and by implementing actions recommended for the Sacramento River, Delta, and Suisun Mash ecological management zones. It is important to note that Mill Creek's undisturbed condition offers holding and spawning habitat which is essentially unchanged from historic times. Restoration of the creek's anadromous fish populations may depend on the success of downstream restoration actions.

DEER CREEK ECOLOGICAL MANAGEMENT UNIT

The Deer Creek Ecological Unit is one of the more important ecological units in the Butte Basin Ecological Management Zone. It provides for highly valued populations of spring-run chinook salmon and steelhead, both of which are problems in the Delta, and populations of other chinook salmon and resident native fish. The vision for Deer Creek is to increase chinook salmon and steelhead runs by maintaining adequate streamflows, spawning gravels, fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This is being accomplished by a locally sponsored comprehensive watershed management and restoration program which is supported by many state and federal agencies.

DEER CREEK WATERSHED DEMONSTRATION PROGRAM: Deer Creek has been tentatively selected as a demonstration watershed for the CALFED Stage 1 (first seven years) Implementation Program. During Stage 1, CALFED will support ongoing management and restoration efforts in the watershed. Success in Stage 1 will set the stage for subsequent implementation phases as information derived in the Deer Creek watershed will have broad application in designing and implementing similar programs in other watersheds throughout the Sacramento Valley.

Cumulatively, an investment in Deer Creek during Stage 1 will provide direct benefits to the creek and provide the types of restoration information needed to successfully move the Ecosystem Restoration Program into subsequent implementation phases. A few of the lessons to be learned in the Deer Creek watershed include how to improve overall watershed health; how to integrate local, state, federal, and private efforts in a large-scale restoration program; how to design and implement actions to benefit spring-run chinook salmon and steelhead; and how to best manage ecological processes such as sediment transport and stream meander in a partially modified stream system.

One of the cornerstones to the probable success of this effort is the Deer Creek Watershed Conservancy. The Conservancy is an active organization comprised of landowners within the watershed who have joined together with state and federal resource management agencies to protect and restore the unique ecological attributes of the watershed. Though a stakeholder planning process, the Conservancy has completed a watershed management plan including and existing conditions report and an important watershed management strategy which outlines actions to protect the future of Deer Creek.

BIG CHICO CREEK ECOLOGICAL MANAGEMENT UNIT

The vision for the Big Chico Creek Ecological Management Unit is to increase runs of chinook salmon and steelhead by providing adequate streamflows, providing unobstructed fish passage, protecting and restoring riparian corridors, and maintaining upper watershed health. This could be accomplished by implementing a locally sponsored comprehensive watershed management and restoration program.

Butte Creek Ecological Management Unit

The vision for the Butte Creek Ecological Management Unit is restoring spring-run chinook salmon and steelhead populations by improving fish passage, increasing and improving streamflow, consolidating and screening diversions, and protecting and restoring the riparian corridor. These improvements will help to restore and maintain habitats needed to support a large population of spring-run chinook salmon and modest populations of fall-run chinook salmon and steelhead trout. Screening will allow continued water diversion for agricultural purposes and for the seasonal flooding of private wetlands and adjacent wildlife refuges. Restoring habitat in Butte Creek would allow the spring-run and fall-run chinook population to achieve increased annual spawning populations.

Butte Sink Ecological Management Unit

The vision for the Butte Sink Ecological Management Unit includes restoring stream channels, streamflow, and riparian SRA habitat, as well as adjacent wetland habitat. ERPP also envisions restoring or maintaining stream channels, streamflows, and SRA habitat to improve rearing and migrating conditions for salmon and steelhead and to improve habitats for resident native fishes, such as the Sacramento splittail.

Visions for Ecological Processes

Central Valley Streamflow: Healthy streamflows are required to sustain sediment transport, stream meander, riparian plant communities and aquatic organisms. The vision is that streamflows will emulate (imitate) the natural seasonal runoff pattern. This would include a late-summer or early fall flow event to sustain ecological processes related to channel maintenance. Such flows would attract and improve the upstream migration of adult chinook salmon.

Coarse Sediment Supply: Natural sediment supplies and gravel recruitment below major dams have been eliminated. Supplementing gravel and other sediments at those sites and reactivating sediment transport in lower creek sections would assist in maintaining ecological processes and important habitat substrates used for invertebrate production and fish spawning. The vision is that existing natural sediment supplies will be protected to maintain stream channel gradients, provide gravel for spawning and invertebrate production, and contribute to maintaining riparian vegetation.

Stream Meander: A natural stream meander process will provide much of the habitat needed to support healthy riparian systems, wildlife, and aquatic species. The vision is that streams will be allowed to naturally migrate consistent with flood control requirements.

Visions for Habitats

Seasonal Wetland Habitat: The vision is that increased seasonal flooding of leveed lands, use of the Butte Sinks's natural flood detention capacity, protection and enhancement of existing wetlands, and development of cooperative programs with local landowners will contribute to increased habitats for waterfowl and other wetland dependent fish and wildlife resources such as shorebird, wading birds, and the giant garter snake.

Riparian and Riverine Aquatic Habitats: Habitats important to anadromous fish production in this ecological zone are impaired by land use activities, including developments along the stream corridors. Improvements are needed to restore riparian, shaded riverine (of rivers) aquatic (SRA), and woody debris habitats. These, in turn, will support improved aquatic species survival. The vision is

that the riparian system will provide shading to moderate water temperatures, provide habitat for aquatic species, and provide a migration corridor for birds and other terrestrial species.

FRESHWATER FISH HABITAT: Freshwater fish habitat is an important component needed to ensure the sustainability of resident native and anadromous fish species. The upper reaches of creeks in Butte Basin Ecological Management Zone are typical of salmon-steelhead streams and the lower section are typical of fall chinook salmon spawning stream (Moyle and Ellison 1991). The quality of freshwater fish habitat in these creeks will be maintained through actions directed at streamflows, coarse sediment supply, stream meander, natural floodplain and flood processes, and maintaining and restoring riparian and riverine aquatic habitats.

ESSENTIAL FISH HABITAT: The streams in this ecological management zone have been identified as Essential Fish Habitat (EFH) based on the definition of waters currently or historically accessible to salmon (National Marine Fisheries Service 1998). Key features of EFH to maintain or restore in these creeks include substrate composition; water quality; water quantity, depth and velocity; channel gradient and stability; food; cover and habitat complexity; space; access and passage; and flood plain and habitat connectivity.

AGRICULTURAL LANDS: Improving habitats on and adjacent to agricultural lands in the Butte Basin Ecological Management Zone will benefit native waterfowl and wildlife species. Emphasizing certain agricultural practices (e.g., winter flooding and harvesting methods that leave some grain in the fields) will also benefit many wildlife that seasonally use these important habitats.

VISIONS FOR REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS: Removing water through unscreened diversions is a direct source of young fish mortality. Reducing these losses would contribute to overall ecosystem health by promoting sustainable fisheries and higher population levels. The vision is that alternative water sources will reduce reliance on instream diversions and that water will be diverted in a manner that does not impair efforts to restore aquatic species and riparian habitat.

DAMS AND OTHER STRUCTURES: Improve the opportunity for the successful upstream and downstream migration of anadromous fish species. The vision is that instream structures will not impair the up- and downstream migration of aquatic species.

HARVEST OF FISH AND WILDLIFE: The legal and illegal harvest of chinook salmon and steelhead in the streams, Bay-Delta, and ocean constrain the recovery of wild populations. Harvest rate reductions will be necessary to allow recovery of populations. The vision is that harvest will not impair efforts to rebuild chinook salmon and steelhead populations.

ARTIFICIAL PROPAGATION OF FISH: The artificial production of chinook salmon and steelhead supports important sport and commercial fisheries and mitigates loss of salmon and steelhead habitat that resulted from dam construction. Due to release practices, fish from several Central Valley hatcheries supplement the naturally spawning salmon and steelhead in the Sacramento River and its tributaries. Hatchery salmon and steelhead may impede the recovery of wild populations by competing with wild stocks for resources. Hatchery-raised stocks, because of interbreeding, may not be genetically equivalent to wild stocks or may not have the instincts to survive in the wild. If these stocks breed with wild populations, overall genetic integrity suffers.

Improvements in hatchery practices are necessary to ensure recovery of wild salmon and steelhead populations. The vision is that hatchery practices throughout the Sacramento Valley will not impair the genetic integrity or identity of chinook salmon and steelhead in the Butte Basin Ecological Management Zone.

VISIONS FOR SPECIES

FALL-RUN CHINOOK SALMON: The vision for fall-run chinook salmon is to recover all stocks presently proposed for listing under the ESA, achieve naturally spawning populations levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and the use fully existing and restored habitat. Fall-run chinook will directly benefit from restoration actions to improve ecological processes and habitat, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that fall-run chinook salmon will be sustained at levels that fully use existing and restored habitat.

SPRING-RUN CHINOOK SALMON: The vision for spring-run chinook salmon is to recover this State-listed threatened species, achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats. Spring-run chinook will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that adult and juvenile spring-run chinook salmon will fully use existing and restored habitat.

STEELHEAD: The vision for steelhead it to recover this species listed as threatened under the ESA and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that use fully existing and restored habitats. Steelhead will directly benefit from restoration actions to improve ecological processes and habitats, and by reducing stressors that reduce juvenile and adult fish survival. The vision is that steelhead will fully use existing and restored habitat.

LAMPREY: The vision for anadromous lamprey is to maintain and restore population distribution and abundance to higher levels than at present. The vision is also to better understand life history and identify factors which influence abundance. Lamprey are a California species of special concern. Because of limited information regarding their status, distribution, and abundance, the vision is that additional monitoring or research will provide the data necessary to better manage these species and their habitat.

NATIVE ANURAN AMPHIBIANS: The vision for the native anuran species is to stop habitat loss and the introduction of other species that prey on the different life stages of these amphibians. Ongoing surveys to monitor known populations and find additional populations is essential to gauge the health of the species in this group. To stabilize and increase anuran populations, non-native predator species should be eliminated from historic habitat ranges. Increasing suitable habitat and maintaining clean water supplies that meet the needs of the various species in this group is essential.

NATIVE RESIDENT FISH: The vision for native resident fish species is to maintain and restore by distribution and abundance of species such as Sacramento blackfish, hardhead, tule perch, Sacramento sucker, and California roach.

NEOTROPICAL MIGRATORY BIRDS: The vision for neotropical migratory birds is to maintain and increase populations through restoring habitats on which they depend.

GIANT GARTER SNAKE: The vision for the giant garter snake is to contribute to the recovery of this State and federally listed threatened species in order to contribute to the overall species richness and diversity. Achieving this vision will reduce the conflict between protection for this

species and other beneficial uses of land and water in the Bay-Delta. Protecting existing and restoring additional suitable wetland and upland habitats will be critical to achieving recovery of the giant garter snake. The proposed restoration of aquatic, wetland, riparian, and upland habitats in the Butte Basin Ecological Management Zone will help in the recovery of these species by increasing habitat quality and area.

WATERFOWL: The vision for waterfowl is to maintain and restore healthy populations at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses consistent with the goals and objectives of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Increase use of the Butte Basin Ecological Management Zone, particularly in the Butte Sink Ecological Management Unit, and possibly increases in some populations would be expected.

PLANT SPECIES AND COMMUNITIES: The vision for plan species and communities is to protect and restore these resources in conjunction with efforts to protect and restore wetland and riparian and riverine aquatic habitats.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

WATERSHED ORGANIZATIONS

MILL CREEK CONSERVANCY

The Mill Creek Conservancy is spearheading a cooperative approach to watershed management with special emphasis on protecting and enhancing chinook salmon and steelhead habitat. In December 1994, the Conservancy developed a Memorandum of Understanding (MOU) to create a Mill Creek Watershed Management Strategy. There are 17 partners to the MOU, including the U.S. Forest Service, California Department of Fish and Game (DFG), Bureau of Land Management, California Department of Water Resources (DWR), The Nature Conservancy, Natural Resource Conservation Service, Los Molinos School District, and others. In 1995, the Conservancy secured funding and developed a work program for a cooperative, local resource management approach. In 1996, a wide range of stakeholders participated in eight Scoping Study sessions to discuss goals and project priorities. The result was the *Mill Creek Watershed Management Strategy Report,* which contained 13 recommendations from the Watershed Advisory Committee. The USFWS, through the CVPIA, has provided funding for riparian restoration projects along lower Mill Creek. Planting and monitoring will be done over a three-year period.

DEER CREEK WATERSHED CONSERVANCY

The Deer Creek Watershed Conservancy was created by the property owners within the drainage to protect Deer Creek's unique ecological values. The Conservancy provides a forum for all stakeholders to become involved in the watershed and to share ideas regarding land use decisions. The processes used by the Conservancy helps build a common information base, keeps communication channels open, and establishes trust and credibility among those wishing to protect and enhance the watershed. The first act of this conservancy was to author and initiate legislation to prevent the construction of any new dams within the watershed.

BUTTE CREEK WATERSHED CONSERVANCY

The Butte Creek Watershed Conservancy was formed to provide a forum for communication among stakeholders and property owners in the

watershed and to develop a watershed planning and management program.

Big Chico Creek Watershed Alliance

The Big Chico Creek Watershed Alliance was sponsored by the City of Chico to address specific problems in the watershed. Still active, it has the potential to serve as the public forum to bring together stakeholders, landowners, and technical experts to develop a watershed management program for Big Chico Creek.

Four Pumps Agreement

(Agreement Between the Department of Water Resources and the Department of Fish and Game to Offset Direct Fish Losses in Relation to the Harvey O. Banks Delta Pumping Plant.) This agreement between the Departments of Water Resources and Fish and Game is a mutually beneficial program to protect and restore habitat for anadromous fish, particularly for chinook salmon. Project-by-project funding is available through this agreement. Projects that provide quantifiable benefits to spring- and fall-run chinook salmon, within specified cost-benefit parameters, are generally approved for funding.

Maintaining and restoring the ecological health of the Butte Basin Ecological Management Zone units will heavily depend on local watershed groups. The ERPP encourages similar watershed groups on Paynes and Antelope Creeks. Efforts in the Butte Basin will be linked to the California Waterfowl Association, Ducks Unlimited, The Nature Conservancy, and the California rice industry. Overall efforts will require cooperation from resource agencies, such as DFG, DWR, U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NMFS), as well as participation and support from the U.S. Bureau of Reclamation (Reclamation), the Natural Resources Conservation Service, and other private organizations, water districts, and individual landowners. These groups are expected to work together to maintain and restore streamflows and fish and wildlife habitat, reduce impacts of diversions, and minimize poaching and habitat and water quality degradation in basin streams. ERPP may provide supporting funding for enhancing streamflows, reducing fish passage problems, screening diversions, restoring habitats, and increasing Fish and Game Code enforcement to protect recovering populations of salmon and steelhead.

Central Valley Project Improvement Act

The U.S. Fish and Wildlife Service (USFWS) and the Bureau of Reclamation (Reclamation) are implementing the Central Valley Project Improvement Act (CVPIA), which provides for restoration of habitats and species and elimination of many stressors. Key elements of the CVPIA program include the Anadromous Fish Restoration Program (USFWS 1997) and the Anadromous Fish Screening Program. The CVPIA calls for doubling the salmon and steelhead populations in the Butte Basin by 2002.

Salmon, Steelhead and Anadromous Fisheries Program Act

Established in 1988 by Senate Bill 2261, this Act directs the DFG to implement measures to double the numbers of salmon and steelhead present in the Central Valley (CDFG 1993). The DFG's salmon and steelhead restoration program includes cooperative efforts with local governments and private landowners to identify problem areas and assist in obtaining funding for feasibility studies, environmental permitting, and project construction.

Other efforts to improve habitat and reduce stressors will be coordinated with existing state and federal programs and with stakeholder organizations. Their objectives include restoring

Central Valley habitat and fish and wildlife populations.

Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan have developed objectives for wetlands in the Butte Basin Ecological Management Zone. These objectives are consistent with the ERPP targets developed for this Ecological Management Zone.

CALFED Bay-Delta Program

CALFED has funded approximately 20 ecosystem restoration projects in Butte Basin. Many of these projects address improving fish passage and restoring riparian habitat. One of the more significant projects constructed a siphon to pass an irrigation canal under Butte Creek, removed five diversion dams, and eliminated 12 unscreened diversion for the Western Canal Irrigation District.

Other Programs

- Lassen National Forest Land and Resource Management Plan.
- National Water Quality assessment Program-the Sacramento River Basin.
- Redding Resource Management Plan.
- Deer Creek Water Exchange Project.
- The Watershed Management Initiative.
- California Rivers Assessment (CARA).
- Rangeland Water Quality Management Plan.
- Sierra Nevada Ecosystem Project.
- Sacramento Coordinated Water Quality Monitoring Program.
- Sacramento River Toxic Pollutant Control Program.
- Sacramento River Watershed Program.
- Tehama County General Plan.
- Tehama County Groundwater Management Plan.

Linkage to Other Ecological Management Zones

Many of the resource elements in the Butte Basin Ecological Management Zone depend heavily on conditions or elements in other zones. Anadromous fish, for example, are highly migratory and depend on conditions in the mainstem Sacramento River, Delta, San Francisco Bay, and nearshore Pacific Ocean. Because these fish are affected by stressors throughout their range, such as unscreened diversions, contaminants, water quality, harvest, and a variety of other factors, restoring anadromous fish populations in the Butte Creek Ecological Management Zone will require efforts in other zones.

Reducing or eliminating stressors in the downstream Ecological Management Zones and improving or restoring downstream habitat are important to restoring healthy fish, wildlife, and plant communities in the Butte Basin Ecological Management Zone.

Restoration Targets, and Programmatic Actions

Ecological Processes

Central Valley Streamflow

Target 1: Increase spring and fall flow in Paynes Creek (◆).

Programmatic Action 1A: Develop a cooperative approach to increase flow in Paynes Creek by acquiring water from willing sellers or by developing alternative supplies.

Target 2: Increase flow in Antelope Creek during October 1 through June 30 (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative approach to evaluate opportunities to increase flow in Antelope Creek. This involves acquiring water from willing sellers or providing alternative water supplies to diverters during the upstream and downstream migration of adult and juvenile spring- and fall-run chinook salmon and steelhead trout.

TARGET 3: Increase the flow in Mill Creek (◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative approach to increase flow in the lower 8 miles of Mill Creek. This involves acquiring water from willing sellers or by providing alterative water supplies to diverters during the upstream migration of adult salmon and steelhead.

TARGET 4: Increase flow in the lower 10 miles of Deer Creek (◆).

PROGRAMMATIC ACTION 4A: Develop a cooperative approach to increase flow in the lower section of Deer Creek. This involves innovative means to provide alternative supplies during the upstream migration of adult spring-run and fall-run chinook salmon and steelhead trout.

TARGET 5: Increase flow in Butte Creek (◆◆).

PROGRAMMATIC ACTION 5A: Develop a cooperative approach to increase flow in Butte Creek by acquiring water from willing sellers.

TARGET 6: Maintain a minimum year-round flow of 40 cfs in Butte Creek between the Centerville Diversion Dam and the Centerville Powerhouse (◆◆◆).

PROGRAMMATIC ACTION 6A: Develop a cooperative program with PG&E to maintain a minimum flow in Butte Creek below the Centerville Diversion Dam.

TARGET 7: Develop and implement comprehensive watershed management programs to protect water quality, increase summer base flows, and protect and restore other resources such as riparian vegetation.

PROGRAMMATIC ACTION 7A: Support local groups in funding and developing watershed management plans including support for watershed coordinators.

RATIONALE: *The streams in the Butte Basin Ecological Management Zone provide extremely valuable habitat for spring-run chinook salmon and steelhead trout. One of the key attributes of streamflow in this Ecological Management Zone is providing for successful upstream passage of adult fish. In addition, flow is the power that drives many ecological functions and processes linked to stream channel morphology, riparian communities, and fish habitat. Many of the diversions on these streams are for agricultural purposes, and alternative water supplies during important periods could permit flow to remain in the creek while alternative sources are provided. The lower watersheds of many of these streams are being subdivided, and additional demands are being placed on the limited water supplies and instream flows. Two important periods are during the upstream migration of adult spring-run chinook salmon and the downstream migration of yearling spring-run chinook salmon and steelhead, which typically occurs in late winter and early spring. Water diversions often shorten the migration season, when streamflows naturally decline. This is the period when supplemental or alternative water supplies could be best used.*

COARSE SEDIMENT SUPPLY

TARGET 1: Develop a cooperative program to replenish spawning gravel in Big Chico Creek. Especially target stream reaches that have been modified for flood control so that there is no net loss of sediments transported through the Sycamore, Lindo Channel, and Big Chico Creek split (◆◆).

PROGRAMMATIC ACTION 1A: Assist in the redesign and reconstruct the flood control box

culvert structures on Big Chico Creek near the Five-Mile Recreation Area to allow the natural downstream sediments transport.

TARGET 2: Develop a cooperative program to improve fall-run chinook salmon spawning habitat in the lower 8 miles of Mill Creek (◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to improve chinook salmon spawning habitats in lower Mill Creek by reactivating and maintaining natural sediment transport processes.

TARGET 3: Improve spawning gravel and gravel availability in Butte Creek (◆◆).

PROGRAMMATIC ACTION 3A: Develop a cooperative program to improve spawning habitat in Butte Creek by maintaining natural sediment transport processes.

RATIONALE: *Gravel transport and deposition processes in Butte Basin Ecological Management Zone streams are essential. These processes maintain spawning and rearing habitats of spring-run and fall-run chinook salmon, steelhead trout, and other native fishes. Opportunities to maintain and restore gravel recruitment are possible by manipulating natural processes and controlling or managing environmental stressors that adversely affect gravel recruitment.*

STREAM MEANDER AND FLOODPLAIN

TARGET 1: Preserve or restore the 50- to 100-year floodplains along the lower reaches of streams in the Butte Basin Ecological Management Zone, and construct setback levees to reactivate channel meander in areas presently confined by levees (◆◆).

PROGRAMMATIC ACTION 1A: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Antelope Creek would facilitate fish passage by minimizing water infiltration through the streambed and maintaining flow connection with the Sacramento River.

PROGRAMMATIC ACTION 1B: Cooperatively evaluate whether a more defined stream channel in the lower 10 miles of Deer Creek would facilitate stream meander, channel-floodplain interactions, gravel recruitment and transport, and riparian regeneration.

RATIONALE: *Stream meander belts are the areas in which natural bank erosion and floodplain and sediment bar accretions occur along streams. Natural stream meander belts in alluvial areas of the Butte Basin Ecological Management Zone function dynamically. They transport and deposit sediments and provide transient habitats important to aquatic invertebrates and fish. They also provide and maintain surfaces that are colonized by natural vegetation that supports wildlife. The lower valley stream reaches in this Ecological Management Zone serve as important migratory corridors to the upper watersheds for spring-run chinook salmon and steelhead and provide spawning substrate for fall-run chinook salmon.*

HABITATS

SEASONAL WETLANDS

TARGET 1: Assist in protecting 10,000 acres of existing seasonal wetland habitat through fee acquisition or perpetual easements consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 1A: Develop and implement a cooperative program to improve management of 10,000 acres of existing, degraded seasonal wetland habitat.

TARGET 2: Develop and implement a cooperative program to enhance 26,150 acres of existing public and private seasonal wetland

habitat consistent with the goals of the Central Valley Habitat Joint Venture and the North American Waterfowl Management Plan (◆◆).

PROGRAMMATIC ACTION 2A: Restore and manage seasonal wetland habitat throughout the Ecological Management Zone.

RATIONALE: *Restoring seasonal wetland habitats along with aquatic, permanent wetland, and riparian habitats is an essential element of the restoration strategy for the Butte Basin Ecological Management Zone. Restoring these habitats will also reduce the amount and concentrations of contaminants that could interfere with restoring the ecological health of the aquatic ecosystem. Seasonal wetlands support a high production rate of primary and secondary food species and large blooms (dense populations) of aquatic invertebrates.*

Wetlands that are dry in summer are also efficient sinks for the transformation of nutrients and the breakdown of pesticides and other contaminants. The roughness of seasonal wetland vegetation filters and traps sediment and organic particulates. Water flowing out from seasonal wetlands is typically high in foodweb prey species concentrations and fine particulate organic matter that feed many Delta aquatic and semiaquatic fish and wildlife. To capitalize on these functions, most of the seasonal wetlands of the Butte Basin Ecological Management Zone should be subject to periodic flooding and overland flow from river floodplains.

RIPARIAN AND RIVERINE AQUATIC HABITATS

TARGET 1: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Mill Creek (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to restore and maintain riparian habitat along Mill Creek by acquiring conservation easements or by voluntary landowner participation.

TARGET 2: Develop a cooperative program to restore and maintain riparian habitat along the lower 10 miles of Deer Creek (◆◆◆).

PROGRAMMATIC ACTION 2A: Develop a cooperative program to restore and maintain riparian habitat along Deer Creek by acquiring conservation easements or by voluntary landowner participation.

TARGET 3: Develop a cooperative program to restore and maintain riparian habitat along Big Chico Creek (◆◆◆).

PROGRAMMATIC ACTION 3A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Big Chico Creek.

TARGET 4: Develop a cooperative program to restore and maintain riparian habitat along Butte Creek (◆◆◆).

PROGRAMMATIC ACTION 4A: Cooperate with local landowners to encourage revegetation of denuded stream reaches and to establish, restore, and maintain riparian habitat on Butte Creek.

RATIONALE: *Many wildlife species, including several listed as threatened or endangered under the State and federal Endangered Species Acts (ESAs), and several special-status plant species in the Central Valley, depend on or are closely associated with riparian habitats. Riparian habitats support a greater diversity of wildlife species than all other habitat types in California. Riparian habitat degradation and loss have substantially reduced the habitat area available for associated wildlife species. This habitat loss has reduced water storage, nutrient cycling, and foodweb support functions.*

FRESHWATER FISH HABITAT AND ESSENTIAL FISH HABITAT

TARGET 1: Maintain and improve existing freshwater fish habitat and essential fish habitat through the integration of actions described for ecological processes, habitats, and stressor reduction or elimination.

PROGRAMMATIC ACTIONS: No additional programmatic actions are recommended.

RATIONALE: *Freshwater fish habitat and essential fish habitat are evaluated in terms of their quality and quantity. Actions described for ecological processes, stressor reduction, and riparian and riverine aquatic habitat should suffice to maintain and restore freshwater fish habitat and essential fish habitat.. For example, maintaining freshwater and essential fish habitats is governed by actions to maintain streamflow, improve coarse sediment supplies, maintain stream meander, maintain or restore connectivity of creeks in this ecological management zone and their floodplains, and in maintaining and restoring riparian and riverine aquatic habitats.*

AGRICULTURAL LANDS

TARGET 1: Cooperatively manage 108,832 acres of agricultural lands (◆◆).

PROGRAMMATIC ACTION 1A: Increase the area of rice fields and other crop lands flooded in winter and spring to provide high-quality foraging habitat for wintering and migrating waterfowl and shorebirds and associated wildlife.

PROGRAMMATIC ACTION 1B: Convert agricultural lands in the Butte Basin Ecological Management Zone from crop types of low forage value for wintering waterfowl and other wildlife to crop types of greater forage value.

PROGRAMMATIC ACTION 1C: Defer fall tillage on rice fields in the Butte Basin Ecological Management Zone to increase the forage for wintering waterfowl and associated wildlife.

RATIONALE: *Following the extensive loss of native wetland habitats in the Central Valley, some wetland wildlife species have adapted to the artificial wetlands of some agricultural practices and have become dependent on these wetlands to sustain their populations. Agriculturally created wetlands include rice lands; fields flooded for weed and pest control; stubble management; and tailwater circulation ponds.*

Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the survival rates of overwintering wildlife and strengthen them for migration, thus improving breeding success (Madrone Associates 1980)

Creating small ponds on farms with nearby waterfowl nesting habitat but little brood habitat will increase production of resident waterfowl species when brood ponds are developed and managed properly. Researchers and wetland managers with the DFG, U.S. Fish and Wildlife Service and the California Waterfowl Association have found that well managed brood ponds produce the high levels of invertebrates needed to support brooding waterfowl. Other wildlife such as the giant garter snake will also benefit. Restoring suitable nesting habitat near brood ponds will increase the production of resident waterfowl species.

Restoring nesting habitat, especially when it is near brood ponds, will increase the production of resident waterfowl species. When the restored nesting habitat is properly managed, large, ground predators are less effective in preying on eggs and young of waterfowl and other ground nesting birds. Managing agricultural lands to increase forage for waterfowl and other wildlife will increase the overwinter survival rates of wildlife and strengthen them for migration, thus improving breeding success (Madrone and Assoc. 1980)

REDUCING OR ELIMINATING STRESSORS

WATER DIVERSIONS

TARGET 1: Improve the survival of chinook salmon and steelhead in Butte Creek by helping to install positive-barrier fish screens (◆◆◆).

PROGRAMMATIC ACTION 1A: Improve the survival of juvenile chinook salmon and steelhead in Butte Creek by helping to the install screened portable pumps as an alternative to the Little Dry Creek diversion.

PROGRAMMATIC ACTION 1B: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at the Durham-Mutual Diversion Dam.

PROGRAMMATIC ACTION 1C: Increase the survival of juvenile chinook salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Adams Dam.

PROGRAMMATIC ACTION 1D: Increase the survival of juvenile salmon and steelhead in Butte Creek by helping local interests to install positive-barrier fish screens at Gorrill Dam.

PROGRAMMATIC ACTION 1E: Increase the survival of juvenile salmon and steelhead in Butte Creek by evaluating the need to install a positive-barrier fish screen at White Mallard Dam.

PROGRAMMATIC ACTION 1F. Increase the survival of juvenile salmon and steelhead in the Sutter Bypass by evaluating the need to install positive barrier fish screens on diversions.

RATIONALE: *Diverting, storing, and releasing water in the watershed directly affects fish, aquatic organisms, and nutrient levels in the system and indirectly affects habitat, foodweb production, and species abundance and distribution. Diversions cause water, nutrient, sediment, and organism losses. Seasonal and daily water release patterns from storage may affect habitat, water quality, and aquatic organism survival. Flood control releases into bypasses also cause adult and juvenile fish stranding.*

DAMS AND OTHER STRUCTURES

TARGET 1: Improve chinook salmon and steelhead survival in Antelope Creek by developing a cooperative program to reduce the use of seasonal diversion dams by 50% during the late spring, early fall, and winter (◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the reduced use of seasonal diversion dams that may be barriers to migrating chinook salmon and steelhead in Antelope Creek by acquiring water rights or providing alternative sources of water.

TARGET 2: Develop a cooperative program to improve the upstream passage of adult chinook salmon and steelhead in Big Chico Creek by providing access to 100% of habitat located below natural barriers (◆◆).

PROGRAMMATIC ACTION 2A: Repair or reconstruct the fish ladders in Big Chico Creek to improve the upstream passage of adult spring-run chinook salmon and steelhead trout.

PROGRAMMATIC ACTION 2B: Repair the Lindo Channel weir and fishway at the Lindo Channel box culvert at the Five Mile Diversion to improve upstream fish passage.

TARGET 3: Develop a cooperative approach to ensure unimpeded upstream passage of adult spring-run chinook salmon and steelhead in Mill Creek (◆◆◆).

PROGRAMMATIC ACTION 3A: Cooperatively develop and implement an interim fish passage corrective program at Clough Dam on Mill Creek

until a permanent solution is developed cooperatively with the landowners.

TARGET 4: Develop a cooperative program to improve the upstream passage of adult spring-run chinook salmon and steelhead in Butte Creek to allow access to 100% of the habitat below the Centerville Head Dam (◆◆◆).

PROGRAMMATIC ACTION 4A: Increase the opportunity for the successful upstream passage of adult spring-run chinook salmon and steelhead on Butte Creek by developing a cooperative program to evaluate the feasibility of removing diversion dams, providing alternative sources of water, or constructing new high-water-volume fish ladders.

PROGRAMMATIC ACTION 4B: Improve chinook salmon and steelhead survival and passage in Butte Creek by cooperatively developing and evaluating operational criteria and potential modifications to the Butte Slough outfall.

PROGRAMMATIC ACTION 4C: Increase chinook salmon survival in Butte Creek by cooperatively helping local interests to eliminate stranding at the drainage outfalls in the lower reach.

RATIONALE: *Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern.*

HARVEST OF FISH AND WILDLIFE

TARGET 1: Develop harvest management strategies that allow the wild, naturally produced fish spawning population to attain a level that fully uses existing and restored habitat. Focus the harvest on hatchery-produced fish (◆◆◆).

PROGRAMMATIC ACTION 1A: Control illegal harvest by providing increased enforcement efforts.

PROGRAMMATIC ACTION 1B: Develop harvest management plans with commercial and recreational fishery organizations, resource management agencies, and other stakeholders to meet the target.

PROGRAMMATIC ACTION 1C: Reduce the harvest of wild, naturally produced steelhead populations where necessary by marking hatchery-reared fish and instituting a selective fishery.

PROGRAMMATIC ACTION 1D: Evaluate a marking and selective fishery program for chinook salmon.

RATIONALE: *Restoring and maintaining chinook salmon and steelhead populations to levels that fully take advantage of habitat may require restrictions on harvest during, and even after, the recovery period. Stakeholder organizations should help to ensure a balanced and fair allocation of available harvest. Target population levels may preclude existing harvest levels of wild, naturally produced fish. For populations supplemented with hatchery fish, selective fisheries may be necessary to limit the wild fish harvest, while hatchery fish harvest levels reduce their potential to disrupt the genetic integrity of wild populations.*

ARTIFICIAL PROPAGATION OF FISH

TARGET 1: Minimize the likelihood that hatchery-reared salmon and steelhead produced in the Coleman National Fish Hatchery will stray into non-natal streams to protect naturally produced salmon and steelhead (◆◆◆).

PROGRAMMATIC ACTION 1A: Develop a cooperative program to evaluate the benefits of stocking hatchery-reared salmon and steelhead in the Sacramento River and Battle Creek. Stocking

may be reduced in years when natural production is high.

TARGET 2: Limit hatchery stocking if salmon or steelhead populations can be sustained by natural production (◆◆◆).

PROGRAMMATIC ACTION 2A: Augment fall chinook salmon and steelhead populations only when alternative measures are deemed insufficient for populations recovery.

TARGET 3: Minimize further threats of hatchery fish contaminating naturally produced chinook salmon and steelhead stocks (◆◆◆).

PROGRAMMATIC ACTION 3A: Adopt methods for selecting adult spawners for the hatchery from an appropriate cross-section of the available adult population.

RATIONALE: *Hatchery augmentation should be limited to protect recovery and maintenance of wild populations. Hatchery-reared salmon and steelhead may directly compete with and prey on wild salmon and steelhead. Hatchery fish may also threaten the genetic integrity of wild stocks by interbreeding with the wild fish. Although irreversible contamination of the genetics of wild stocks has occurred, additional protective measures are necessary to minimize further degradation of genetic integrity. Because of the extent of development on the Sacramento River and Battle Creek, stocking chinook salmon and steelhead may be necessary to rebuild and maintain stocks to sustain sport and commercial fisheries.*

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